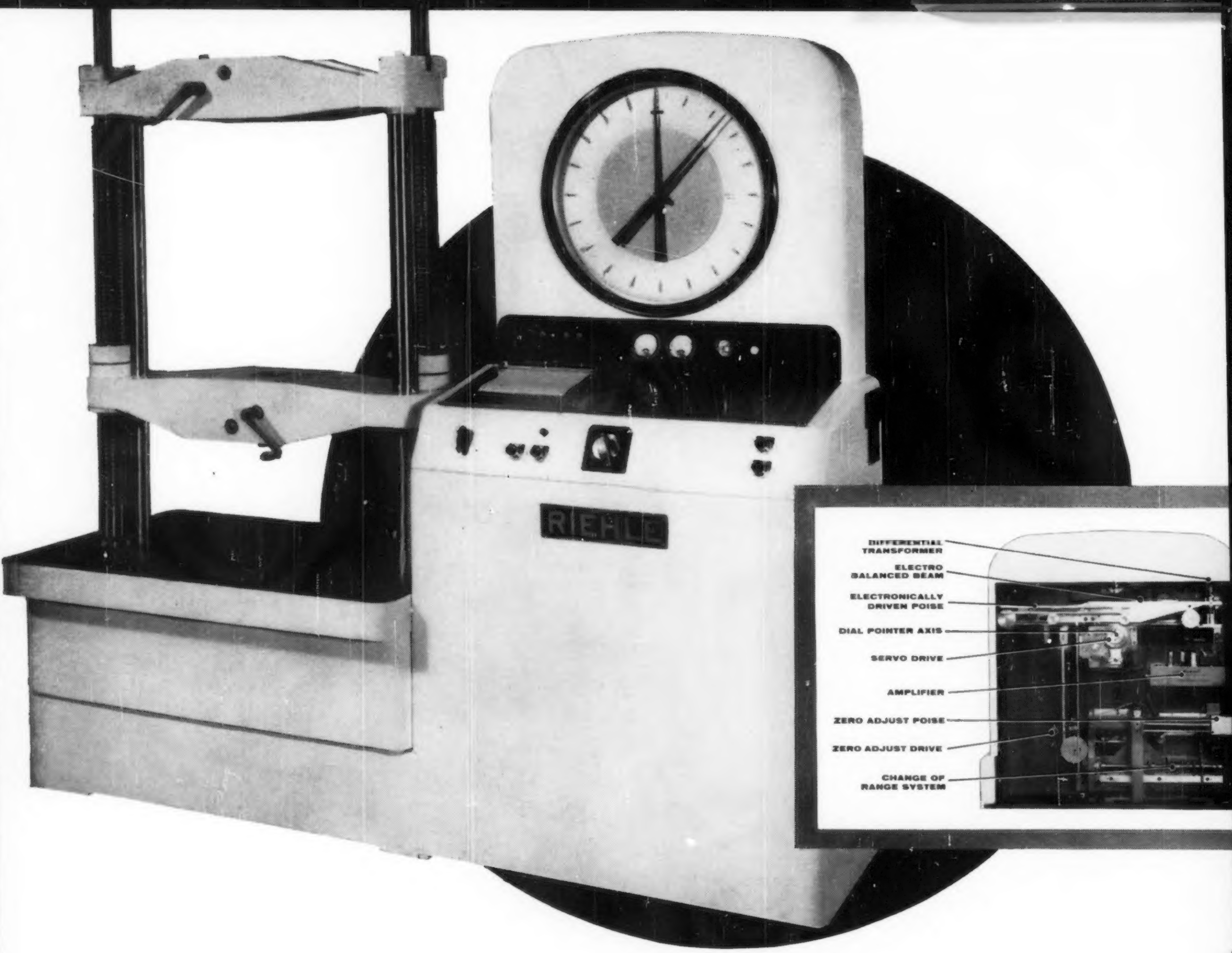
ASTM Bulletin

MAY, 1957
No. 222

60th ANNUAL MEETING
Atlantic City, N. J.
June 17–21

American Society for Testing Materials



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ASTM BULLETIN

MAY 1957

Number 222

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IN THE SOCIETY

GENERAL NEWS NOTES

ASTM Bulletin is indexed regularly by Engineering Index, Inc.
ASTM Bulletin is available on microfilm from University Microfilms, Ann Arbor Mich.

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RMATION CIRCLE 522 ON READER SERVICE CARD PAGE 81

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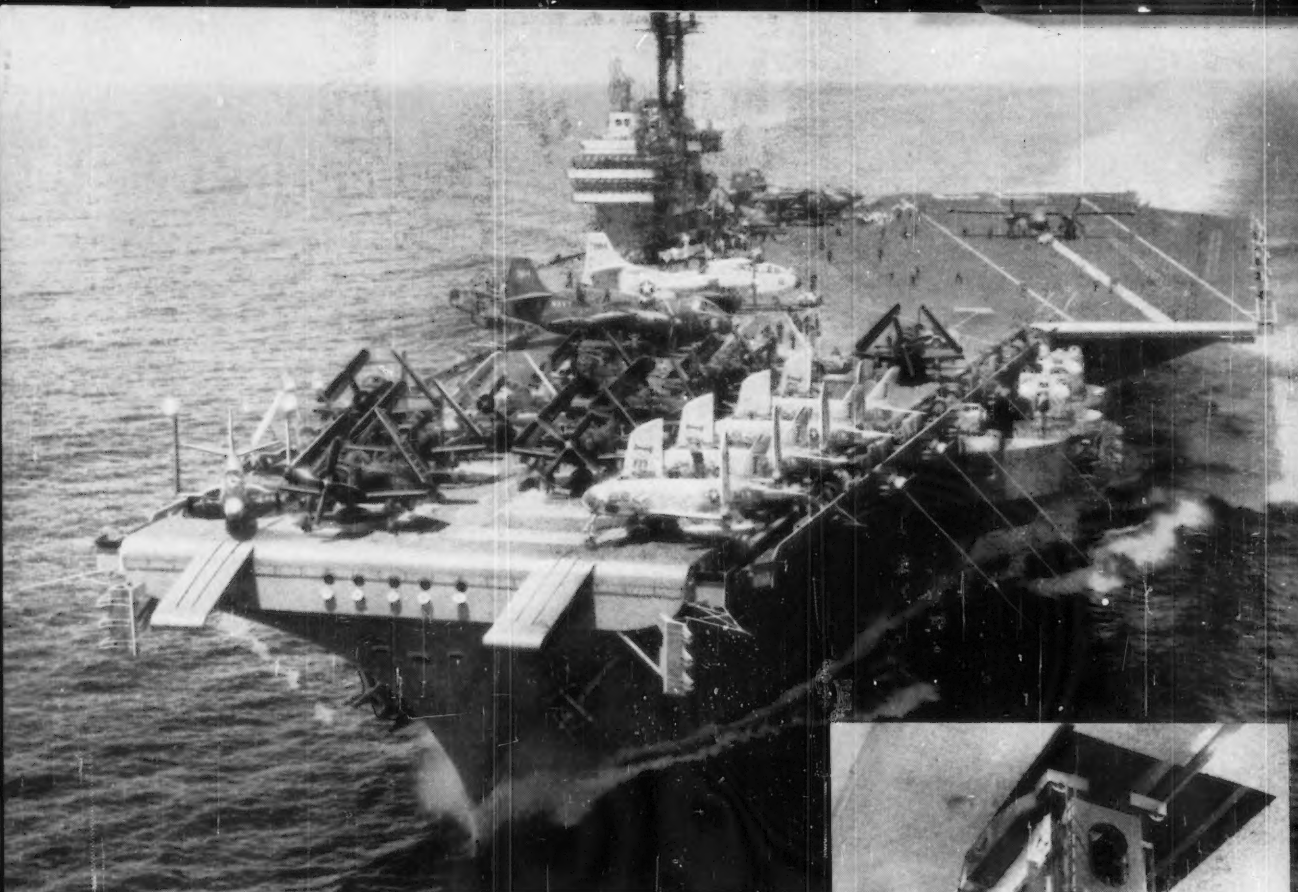
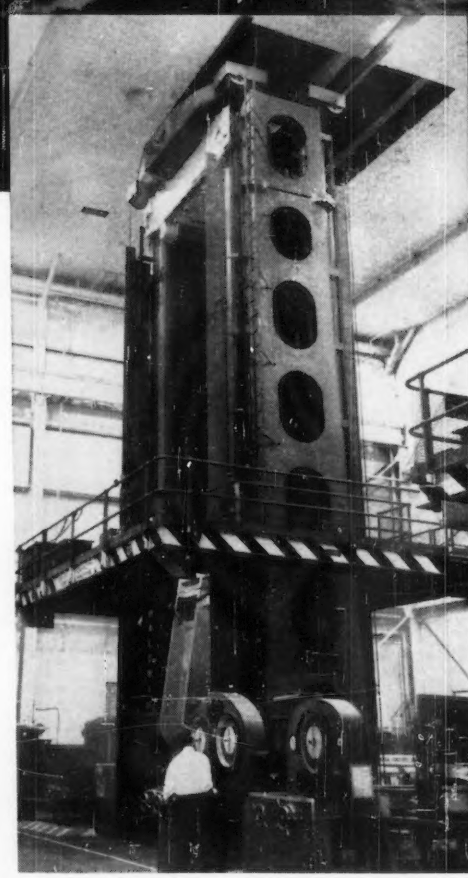


Official Navy photograph



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ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

Number 222 **May 1957**

A Reminder . . .

60th Annual Meeting

ATLANTIC CITY JUNE 17–21

This meeting-at-a-glance outline summarizes the technical, business, and social events of ASTM's 60th Annual Meeting. In addition, a full program of activities is planned for the ladies. For the detailed Provisional Program and the Ladies Program, see the April issue of your ASTM BULLETIN.

	MONDAY, June 17	TUESDAY, June 18	WEDNESDAY, June 19	THURSDAY, June 20	FRIDAY, June 21
MORNING	—10:30 a.m.— 1 Opening Session—General Testing (Report Committee E-1)	7 Symposium on Determination of Gases in Metals 8 Symposium on Large Fatigue Testing Machines and Their Results —12:00 noon— 9 Luncheon Session, President's Address	17 High Temperature Session —11:15 a.m.— 18 Report Session (Reports C-7, C-9, C-13, D-8, D-18, E-5, E-6) —12:00 noon— 19 Luncheon Session, Awards, Medals	24 Symposium on Radiation Effects on Materials —11:30 a.m.— 25 Report Session (Reports C-3, C-8, C-12, C-14, C-16, C-21, C-22, D-24)	—10:30 a.m.— 29 Masonry Session
AFTERNOON	2 Soils Session —4:30 p.m.— 3 Report Session (Reports C-2, C-17, D-13, D-22, D-23, E-12)	10 Symposium on Large Fatigue Testing Machines and Their Results 11 Symposium on Spectrochemical Analysis for Trace Elements —4:30 p.m.— 12 Report Session (Reports A-1, A-9, B-7, E-9, E-11, Jt. Comm. Effect Temp., Jt. Comm. Leather) —5:00 p.m.— 13 Gillett Lecture A. J. Herzig Molybdenum	—2:30 p.m.— 20 High Temperature Session —4:00 p.m.— 21 Report Session (Reports B-1, B-2, B-3, B-5, B-6, B-8, B-9) —4:00 p.m.— 22 Report Session (Reports D-1, D-11, D-14, D-20, D-25, E-3) —4:30 p.m.— 23 Marburg Lecture, E. P. Partridge Water	26 Symposium on Radiation Effects on Materials —4:30 p.m.— 27 Report Session (Reports A-10, E-2, E-13, D-5, D-7, D-12, D-17, D-21)	—12:30 p.m.— 30 Report Session (Reports A-3, A-5, A-6, B-4, C-1, C-11, Adv. Comm. Corrosion) —12:30 p.m.— 31 Report Session (Reports D-2, D-3, D-4, D-6, D-9, D-15, D-16, D-19, F-1)
EVENING	4 Steel Session 5 Fatigue Session 6 Concrete Session	14 Symposium on Spectrochemical Analysis for Trace Elements 15 Non Ferrous Metals Session 16 Concrete Session	Cocktail Party ASTM Dinner Entertainment Dancing	28 Symposium on Determination of Dissolved Oxygen in Water	

NEW ASTM PUBLICATIONS

The ASTM publications described in these columns have just come off press, and may be obtained from Society Headquarters, 1916 Race St., Philadelphia, Pa.

MARBURG LECTURE

Industrial Chemistry, Properties, and Applications of Silicones

Silicones are polymeric materials based on silicon and, because of their unique properties, they extend the useful range of other industrially important polymeric materials. Their expansion into new areas of use provided the basis for the 30th Edgar Marburg Lecture, presented at the June, 1956 Annual Meeting by Charles E. Reed, manager of General Electric's Silicone Products Dept.

Dr. Reed carefully illustrates the fact that, chemically speaking, silicones are constructed and synthesized much like their organic cousins. The point of departure lies in the nature of the silicone bonding forces. This difference in bond strength and mobility accounts for the stability of these materials at high temperatures, their chemical inertness to metals and most reagents, and their very low coefficient of viscosity with temperature.

Silicones may form low-molecular-weight polymeric fluids. Such products have found a wide variety of uses due to their excellent dielectric properties, good temperature stability, and chemical inertness.

Further reaction or crosslinking will form three-dimensional networks of insoluble, infusible elastomers. Data showing chemical and physical properties of these silicone rubber and plastic-like materials are given and illustrations of outstanding uses displayed.

It is probable that silicones will continue to find their major utility in general application areas which make use of their unusual resistance to temperature extremes, inertness, special surface properties, and water repellency. It is certain that the breadth of economic application for silicones will continually increase.

Future developments in silicones will result in materials of greater strength and solvent resistance, and curing at lower temperatures, but with no important sacrifice in electrical or mechanical properties over a wide range of temperature.

Since the Marburg Lecture is no longer included in the *Proceedings*, the lecture, with self covers, is available free of charge to ASTM members. Copies with special covers, may be obtained by members for $1.15. Nonmembers may procure copies for $1.50.

Symposium on Structural Sandwich Construction

The recognized advantages of sandwich construction such as high strength-to-weight ratio and good stiffness factor have greatly spurred advances in its use and application in various industries since 1951 when the last symposium was held by ASTM Committee C-19 on Structural Sandwich Construction.

The aircraft industry has concentrated on problems of supersonic flight such as thermal resistance and stability and the new problem of sonic fatigue. Efforts in the building industry have been mainly in the interpretation of the codes as they affect the introduction of new types of materials—a problem enormously complicated by the multitude of Federal, state, and municipal regulations in existence. In order to introduce the sandwich structures in the building industry, research has been necessary in weathering, durability, stability, and fire resistance, along with a regard for the economic aspects.

Since there are many agencies and industries involved in the fabrication and utilization of these structures, ASTM has realized the continuing need for standardization of test methods and procedures. Committee C-19 sponsored this symposium at the Second Pacific Area National Meeting to acquaint the industry with what has been accomplished in standardization and to act as a sounding board as to what lines of investigation need further emphasis.

Titles and authors of the papers are as follows:

Introduction—*T. P. Pajak*
High Temperature Testing of Adhesives for Aircraft Structural Applications—*J. R. Battalora and D. E. Pulsifer*
Effect of Dimensional Factors and Temperature on the Sheer Strength of Aluminum Honeycomb—*W. Cheorvas and W. C. Plumtree*
Sandwich in the Design of Helicopters—*J. M. Stevens*
Conclusions Derived from Empirical Studies of Bonded Details for Sandwich Construction—*M. L. Sheridan and H. R. Merriman*
Selection of Materials for Architectural Sandwich Panels—*R. E. Parkinson*
Recent Developments in Sandwich Construction Including Heat Resistant Materials—*R. C. Steele*
Methods of Testing Sandwich at Elevated Temperatures—*E. W. Kuenzi*
Metal-to-Resin Adhesion as Determined by a Stripping Test—*W. J. Snodden*
An Ultrasonic Technique for Nondestructive Evaluation of Metal-to-Metal Adhesive Bonds—*J. S. Arnold*
Nondestructive Testing of Bonded Metal Sandwich Materials—*R. Anderson*

Together with discussion, this symposium, STP 201, totals 110 pages. Price: $2.75; to members, $2.00.

Symposium on Wood for Marine Use

Wood, like all other engineering materials, is subject to destructive agents, largely peculiar to itself. In the order of their importance they are decay, fire, insects, and marine borers, mechanical wear, weathering, and chemical decomposition.

Although wood is subject to fungus attack, it does not decay if saturated with water. Submerged wood, therefore, protected from air, does not have this particular problem, but a major difficulty is imposed in preventing impairment by marine organisms.

The marine engineer usually designs his structures for a life of 40 to 50 years, but there is no known preservative which will protect the foundation wood of his structures against *Limnoria*, a crustacean, for more than 5 to 12 years where environmental conditions are favorable to the animals.

The investment in wood piling for docks, piers, etc., is enormous and increasing initial costs of piling and cost of replacement pose a continuing challenge to develop means of obtaining longer life and serviceability.

Because of the extensive use of wood piling on the West Coast, ASTM Committee D-7 on Wood developed this symposium for the Second Pacific Area National Meeting held in Los Angeles in September, 1956. The papers are intended to present a picture of marine borer problems and the difficulties encountered, the results of some special research studies on the nature and distribution of certain organisms, the most susceptible zone of attack, and the effec-

tiveness of certain specific protection procedures.

Titles and authors of the papers are as follows:

- The Distribution and Importance of Marine Wood Borers in the United States—*Robert Menzies and Ruth Turner*
- Marine Exposure Tests of Wood Treated with Various Preservatives—*A. P. Richards*
- Performance Tests of Heavy Metal Compounds as Marine Borer Inhibitors—*T. Roe and E. R. Holden*
- The Importance of the Local Borer Species in Specifying Agents for Protecting Wood from Marine Borers—*Harold Vind, J. Maraoka, J. Casey, and H. Hochman*

Including discussions, this symposium, STP 200, totals 58 pages. Price: $2.; to members, $1.50.

Compilations of Selected ASTM Standards

Rubber and Rubber-Like Materials

Includes all the standard methods of test and specifications developed by ASTM Committee D-11 on Rubber and Rubber-Like Materials. Grouped under specific product headings, the standards cover: processibility tests, chemical and physical tests of vulcanized rubber; aging, weathering, and low-temperature tests; automotive and aeronautical rubber; packing and gasket materials; hose, belting, tape; synthetic elastomers; electrical protective equipment; rubber-coated fabrics; insulated wire and cable; latex foam, sponge, expanded cellular and crude rubber; rubber latex; nonrigid plastics; electrical tests; general test methods; and nomenclature and definitions.

Proposed Methods of Testing Rubber Thread, and the Regulations Governing Committee D-11 appear in appendices. 846 pages. Price: $7; to members, $5.25.

Electrical Insulating Materials

The 80 specifications and methods of test prepared by ASTM Committee D-9 on Electrical Insulating Materials are included in this compilation along with three appendices: (1) proposed recommendations for writing statements on the usefulness of tests of these materials; (2) proposed methods of test for dielectric constant and dissipation factor of aviation fuels; (3) proposed specifications for electrical insulating paper sulfate tissue for capacitor dielectric.

The standards cover: insulating shellac and varnish; plates, sheets, tubes, rods, and molded materials; mineral oils for electrical insulation; ceramic products (glass, porcelain, steatite); solid filling and treating compounds; insulating fabrics and papers; mica products; electrical tests; conditioning, servicing units; textile materials for electrical insulation; and general test methods.

666 pages. Price: $6; to members, $4.50.

Thermal Insulating Materials

The work of Committee C-16 on Thermal Insulating Materials has become increasingly important as use of these materials has expanded. The accumulating research and development work carried on by the committee in the wide variety of materials and installations has resulted in this first edition of a compilation of these standards. They include definitions, symbols, recommended practices, sampling, and methods of test; specifications for cement; batt and blanket; felt; block and board; and insulation for pipes.

216 pages. Price: $3; to members, $2.25.

ACR Notes

Administrative Committee on Research

Research Is Vital to ASTM

By R. C. ALDEN

An outstanding example of ASTM research on materials of engineering was the Symposium on Composition of Petroleum Oils held in February at New Orleans in conjunction with the meeting of Committee D-2 on Petroleum Products and Lubricants. Unlike many ASTM symposia, which are addressed to problems of immediate commercial significance, the New Orleans meeting dealt with new techniques and new materials.

It was with some trepidation that Committee D-2 set up its Research Division IV on Hydrocarbon Analysis immediately following the war. The avowed purpose of this activity was, and is, the standardization of research techniques for the quantitative determination of hydrocarbon types in petroleum products and lubricants and the measurement of the properties of the materials. There were those who considered that such an activity would inevitably lead to hopelessly complex and unnecessary test methods and specifications for petroleum products. Others thought there were plenty of today's problems without taking on tomorrow's problems. Nevertheless, the war had left in every one's mind the great importance of being prepared for even the most fantastic technological developments and so Research Division IV was launched on an experimental basis.

In the ten years that have elapsed, the over-all judgment has been more than vindicated. Research Division IV is one of the most active of the Petroleum Committee's many subdivisions. It has over 40 members, with many more working in its nine sections. It has under its surveillance 16 ASTM standards, of which 12 are full standards, and has published others as information.

One of the great advantages to Committee D-2 of having a real research subcommittee is that it has attracted outstanding workers in research from universities, Government, and industry.

The symposium held in New Orleans considered no pressing or urgent problems. It was a well arranged, deliberative consideration of many things which may or may not be tomorrow's problems. Perhaps its most important significance to ASTM, which stages so many symposia at such high levels of technical competence, is that it represented a longstanding and continuing research activity rather than a sporadic effort.

The writer has previously mentioned that ASTM is engaged in dynamic standardization, as contrasted with the static standardization perceived elsewhere. It is research that makes our ASTM standardization dynamic.

1957 International Conference on Nondestructive Testing

The Second International Conference on Nondestructive Testing will be held in Chicago, November 3 to 8, 1957, in conjunction with the Second World Metallurgical Congress. Sponsor of the Conference is the Society for Nondestructive Testing.

The American Society for Metals is sponsoring the Second World Metallurgical Conference and is also arranging a number of plant tours throughout the United States to take place the two weeks prior to the convention. One tour is of specific interest to those involved in inspection and testing.

Detailed information on the tours can be obtained from either the American Society for Metals, 7301 Euclid Avenue, Cleveland 3, Ohio, or the Society for Nondestructive Testing, Inc., 1109 Hinmann Avenue, Evanston, Ill. The tours are not available to conferees from the United States.

ASTM Bulletin

MAY 1957

NO. 222

NINETEEN-SIXTEEN
RACE STREET
PHILADELPHIA 3, PENNA.

1956 Proceedings

Members who have ordered the annual *Proceedings* of the Society should receive their copies before the Annual Meeting. The 1528-page volume recording the technical accomplishments of the year includes reports and papers together with discussion offered to the Society during the year and accepted for the *Proceedings*. Leading the volume are the Summary of Proceedings for each of the three national meetings held in 1956—the 59th Annual Meeting, the Second Pacific Area National Meeting, and the Buffalo national meeting (Spring Meeting)—listing by title and author the programs for each session.

Following these is the annual President's address in which Clair H. Fellows discussed "The Challenge of Nuclear Energy Accepted by the Electric Power Industry and ASTM." He described the status of a joint effort begun in 1950 to examine the possibility of the development of an economically competitive nuclear-energy heat source for the generation of electric power.

The Annual Report of the Board of Directors highlights matters administrative, technical, and financial, for the benefit of members. Included are records of all meetings held by the Society and its Districts; information on membership gains, publications, honors and awards, and other matters of interest.

Reports of the technical committees, of which there are 70, and their appendices provide a wealth of useful information as do the technical papers and discussions on a wide variety of subjects pertaining to research and testing of materials.

In addition to the papers and reports embodied in the *Proceedings*, there are listed in the table of contents all symposiums published separately as Special Technical Publications (STP's) and all papers published in the ASTM Bulletin.

Although the Society's publications program has expanded greatly in recent years, the *Proceedings* remains the repository of actual information and a record of the Society's work. An important adjunct is a subject and author index to all papers published in any form by the Society in 1956.

It should be emphasized that in addition to reports and technical papers, many of which have been given at the national meetings and some of which have been preprinted, the *Proceedings* contain much discussion not previously published.

Past-President Farmer Celebrates 80th Birthday

We were very pleased recently to join with a number of other members of the Society, particularly some who were closely associated with him, in extending birthday greetings on his 80th birthday to Past-President F. Malcolm Farmer, 331 W. Miner St., West Chester, Pa. President of the Society in 1924, Mr. Farmer contributed a great deal to our technical and administrative progress. He was active in several technical committees, notably D-9 on Electrical Insulating Materials and D-11 on Rubber and Rubber-Like Materials. Mr. Farmer is also a past-president of the American Inst. of Electrical Engineers. He became an Honorary Member of ASTM in 1947.

A personal message from him has this to say: "I always took great satisfaction in my activities in ASTM in my earlier years because of the concrete material value to industry (and therefore the national economy) of the Society's objectives. It is therefore very pleasing to see it grow the way it has. May its growth and prestige continue, and may you and your Staff enjoy many years of satisfaction in participating in that growth."

Preprints in the Mails

The First Installment of preprints of Annual Meeting papers and reports were mailed to all who requested them, on May 10.

The Second and Third Installments will go into the mails on May 29 and June 14.

Schedule of ASTM Meetings

This gives the latest information available at ASTM Headquarters. Direct mail notices of all district and committee meetings customarily distributed by the officers of the respective groups should be the final source of information on dates and location of meetings. This schedule does not attempt to list all meetings of smaller sections and subgroups.

Date	Group	Place
June 6–7	Committee F-1 on Materials for Electron Tubes and Semiconductor Devices	Boston, Mass. (Hotel Kenmore)
June 16–21	**ANNUAL MEETING**	Atlantic City, N. J. (Chalfonte-Haddon Hall)
July 12	Joint Committee on Chemical Analysis by Powder Diffraction Methods	Montreal, Quebec
October 6–10	Committee D-2 on Petroleum Products and Lubricants	Washington, D. C. (Sheraton Park Hotel)
October 6–10	Joint Committee on Petroleum Wax	Washington, D. C. (Sheraton Park Hotel)
October 9–10	Committee B-5 on Copper and Copper Alloys	Boston, Mass. (Statler Hotel)
October 31–November 1	Committee D-14 on Adhesives	Philadelphia, Pa. (Sheraton Hotel)

PROFESSIONAL AMATEUR—*The Biography of Charles Franklin Kettering**

By T. A. Boyd

C. F. Kettering

The editors are pleased to present a special review of a most interesting new book. It is a biography of an ASTM member of 42 years' standing, written by a Past-President and Honorary Member of the Society, and reviewed by a Past-President. All those who have heard Mr. Boyd speak or have read his papers and publications will recognize in this book that his pen has lost none of its deftness. Because of the nature of Boss Ket's activities, engineers and scientists in particular will find this book of keen interest.

THE AUTHOR of this book has portrayed, with skill and an understanding born of long association, the first eighty years of the life of one of the great men of our time. In doing this he has condensed into a genuinely interesting story the life plans, philosophy and accomplishments of a man whose insatiable curiosity, limitless energy, and acknowledged leadership ability forged a career seldom equaled. Outlined for reader interest and continuity, the book is divided, appropriately, into three parts representing periods of time. The Foreword is by Alfred P. Sloan, long a close associate of Kettering.

"Charles Franklin Kettering was born in a farmhouse among the hills of northern Ohio on August 29, 1876. Franklin was chosen as his middle name after an uncle of his. But, if it had stood instead for Benjamin Franklin it would have been prophetic of what he was to become."

This opening paragraph in Chapter I characterizes the humble origin of Charles Kettering. Born in the same relative obscurity as thousands of other boys, he attended country school—barefooted—shared in the farm chores, and early in life demonstrated his capacity for work. He developed, in youth, several qualities that were later to distinguish him from most other men. In addition to his capacity to do work he learned to enjoy hard work. He possessed unusual powers of observation and later acquired a penetrating concentration as applied to experimental work. During his long experience, he has stimulated improved performance in many others through learning to get pleasure from a well done job although the task itself might appear to be dull and routine. A classic example of this is found in the author's reference to Kettering's hiring a tramp to dig post holes for his telephone line gang.

The vagabond, under temporary urge of conscience to repay Kettering for a meal, toyed indifferently with a shovel and finally dug—not a deep and round post hole but rather an irregular depression in the hard ground. Kettering, foreman of the gang, demonstrated to the man how to dig a round, deep, straight, smooth hole; and also how much fun it was to do a good job. The man's interest was aroused with the new challenge, he came to appreciate that work can be fun and as a direct result the ex-hobo stayed on and later became foreman of the construction crew. In a way, this is characteristic of Kettering's method of stimulating associates. Always able, and willing, to do his share of a job, he expected others to take their share as well. He once said, after many years of experience: "I don't want a fellow who has a job working for me. I do want some fellow whom the job has. I want the job to get the fellow, not the fellow get the job."

Throughout the book, the author's care and judgment in the choice of quotations and illustrations from Dr. Kettering's writings and speeches, has added much to the interest of reading.

This biography of Charles Kettering is written in a dynamic way. It is the challenging story of the life work of a man who had the energy and courage—while toiling with the immediate—to keep the ultimate goal in clear view. Few men have comparable ability to size up what appears to be a mass of conflicting experimental evidence, expunge the false and the trivial, and then groom the essentials into the practical model he seeks. The self starter for automobiles is one classic example given, and another is the development of a motor for operating a cash register.

There is an interesting summary of the trials and tribulations with the early Diesel engine in supplying power to trains and trucks. The entire field of fuels as related not only to the Diesel engine but also to the conventional automobile engine was an essential part of these rapidly moving research studies to keep pace with the mechanical developments. These researches had a bearing also on the fundamental concepts of chemistry and physics. Rather than be concerned as to whether data agreed or disagreed with this or that theory, Kettering reasoned out the apparent inconsistencies on a practical, demonstrable basis. This pattern of practical approach to research problems as recalled in this present volume is a continuation of a theme used over a period of years of writing and speaking—a theme that has challenged other investigators to show more concern about finding what the facts *are* and a little less concern perhaps about what the theories *might be*.

This book is a forthright account of one of the foremost technical men of this generation, and the story is written in a warmly human and understanding fashion. Transcending the immediate reader interest of the book will be its inspirational value to readers generally—to young men, particularly. It is the story of the genius of one who, with untiring zeal for finding the proper solutions to technical problems and with audacious courage at the proper time, has brought many of the necessities, some of the comforts, and a few of the luxuries of life within the reach of large numbers of people.

The reading of this book leaves one with a renewed awareness of the vast opportunities for service that await the investigator who has the proper combination of intelligence, technical curiosity, courage, and human understanding and whose outlook on life is beyond the confines of conventional thinking.

As interesting and informative biography, of particular interest to engineers and scientists, the book is rated at the top of the scale by this reviewer. The author, T. A. Boyd, Past-President and Honorary Member of ASTM, is to be congratulated on so fine a book. Written with thoughtful discrimination in material selected, the book holds reader interest throughout. Those fortunate enough to know the author, personally, will appreciate the characteristic good humor that highlights many of the incidents. At the same time, a studious search of the book for some reference to the author, finds no trace, even though Dr. Kettering and the author have been close associates for more than thirty years.

HAROLD L. MAXWELL

* Published in 1957 by E. P. Dutton and Co., 300 4th Ave., New York, N. Y.

Nondestructive Tests in the Field of Nuclear Energy

THE significance of nondestructive testing in the nuclear energy field is the same as the significance of any other type of test used in this application, namely, the need for taking every precaution possible to avoid the use of any defective material in a situation where failure might have tragic consequences. The actual procedures employed and developed have general application. They may have been introduced for the testing of the relatively small amount of production that goes into the nuclear field, but they will have application in many other fields. Some can be used quite generally.

This was recognized by the very interested audience at the Symposium on Nondestructive Tests in Nuclear Energy Field held in Chicago on April 16 to 18. The papers presented as part of the program (some 40 in number) were listed in the February issue of the ASTM BULLETIN. A unique feature of the meeting was the withholding of all discussion at the time of presentation of the papers but with an opportunity for questions to be submitted in writing which formed the basis of a panel discussion on Tuesday and Wednesday evenings. These panel discussions proved to be extremely popular and a valuable part of the meeting.

The discussions will be included in the symposium volume containing the papers. Depending upon the release and approval of manuscripts, including the discussion, it is expected that the symposium volume which is being published by the ASTM will appear some time in the fall. The papers represent contributions from Argonne, Los Alamos, Brookhaven, Oak Ridge, Sandia, Hanford, Battelle, Westinghouse, General Electric, and Savannah River and represent material that has just recently been declassified.

The meetings were sponsored by American Institute of Chemical Engineers, American Nuclear Society, ASTM, Society for Nondestructive Testing, and Atomic Industrial Forum. The Symposium Committee was under the chairmanship of Warren J. McGonnagle, associate physicist, metallurgical division, Argonne Laboratories

Your Committee Officers

A new series—to better acquaint BULLETIN readers with the men whose responsibility it is to direct the indispensible work of the ASTM technical committees.

Committee A-1 on Steel

Chairman—W. F. Collins, Chief, Engineering Services, New York Central System

Vice-Chairman—Jerome J. Kanter, Directing engineer, Engineering Labs., Crane Co.

Vice-Chairman—Claude L. Clark, Metallurgical engineer, Special Steel Developments, Timken Roller Bearing Co.

Secretary—H. L. Fry, Foreman of special tests, Bethlehem Steel Co.

Committee A-9 on Ferro-Alloys

Chairman—Sidney W. Poole, Research metallurgist, Republic Steel Corp.

Vice-Chairman—E. A. Lucas, Vice-president and works manager, Molybdenum Corp. of America

Secretary—W. H. Mayo, Manager, process control metallurgy, United States Steel Corp.

District Activities

PITTSBURGH

The annual Pittsburgh President's Night on April 24 drew a substantial turnout of the District members and their guests to greet President and Mrs. Schatzel and to see the awarding of eight student memberships. Prof. James Rabaldi, University of Pittsburgh, presented the students and the award sponsors to Dr. Schatzel who made the presentations.

Among the recipients were Joseph Schwaighofer and Melvin A. Wilkov, Pennsylvania State University; Edmond B. Collins and Eugene C. Ford, West Virginia University; Robert B. Anderson and Ronald E. Kelley, Carnegie Institute of Technology; and James P. Connor and Emile Monier, University of Pittsburgh.

Dr. Schatzel commented on the continuing interest of ASTM in the development of engineers and scientists and welcomed the students into the fraternity of the 8800 members who comprise ASTM. He pointed out that their association with these men in the research and preparation necessary for the formulation of standards will undoubtedly hold great value for them and that certainly ASTM will benefit by their addition to its ranks.

Hugh Beeghly, Jones and Laughlin Steel Corp., Chairman of the Pittsburgh District, presided at the meeting.

CLEVELAND

President Schatzel addressed a meeting of the District on April 25 in the Hotel Statler. He was presented by L. F. Herron, Herron Testing Laboratories, who is District Chairman, following a dinner in honor of the President and Mrs. Schatzel.

Following dinner, A. L. Batik, Headquarters Staff, described the recent progress of the Society, particularly emphasizing the increasing role that ASTM is playing in nuclear energy. Dr. Schatzel, after awarding student memberships to eight men presented by Professor Harris of Fenn College, delivered an address on "Materials for Electric Power Transmission." He reviewed the uses of copper, aluminum, and steel for cables and described the amazing growth of synthetic rubber and plastics for insulated cables. Throughout his talk he pointed to the significant contributions that ASTM has made in the development of standards to the wire and cable industry.

NEW YORK

John M. Kyle, Jr., chief engineer of the Port of New York Authority, gave an interesting talk to the New York District on April 25 on the plans of the Port Authority for arterial highway expansion and port facilities development. Among the topics included were double decking the George Washington Bridge, the building of a New York Harbor bridge and a progress report on the building of the third Lincoln Tunnel tube. Some of the materials to which consideration was given in this talk were electric wires and cables, bridge strands, asphalt, steel, and cement.

E. P. Pitman, District Chairman presided at the meeting.

NEW ENGLAND

The Spring Meeting, held in conjunction with the Providence Engineering Society and the University of Rhode Island, drew well over 225 students, faculty members, and interested engineers and scientists to the main afternoon session held on the campus of the University of Rhode Island on May 3. In a two-hour session, Executive Secretary R. J. Painter led off the discussion with the topic "Research and Standards—Hand in Hand." Giving descriptions of ASTM's progress, he cited the work done in structural steel, wood pole testing, and copper corrosion.

ASTM President Rudolph A. Schatzel, Rome Cable Corp., briefly outlined the "Engineers' Concern with Materials in War and Peace," stressing the fact that all materials of necessity are used in war and that the standards we now make in peace may well be the standards we have to use in war.

Dr. Schatzel was followed by Vice-President Richard T. Kropf, Belding Heminway Co., who discussed the topic "From Cave Man to Space Man by KOM." Using the thread of KOM (knowledge of materials), Mr. Kropf gave an historical description of the use and the need of knowledge of materials through the centuries. The last speaker, ASTM Director C. R. Stock, American Cyanamid Co., discussed "Presenting Industry's New Products." He described the importance of specifications from both the consumer's and producer's point of view, and described the process by which new products are introduced to the market. During his talk he showed samples of plastic products which appeared similar but, following changes in their environment, deteriorated at different rates.

The speakers were introduced by Prof. E. A. Gramstorff, Northeastern University, and E. F. Walsh, The Narragansett Electric Co., was the Program Committee Chairman.

A dinner at the University of Rhode Island was attended by representatives from the American Chemical Society, American Society of Mechanical Engineers, American Institute of Electrical Engineers, and The Providence Engineering Society. At the evening session, H. C. Harrison, special assistant to the attorney general of the State of Rhode Island and professor of chemistry at the University of Rhode Island, gave a lecture demonstration on "Modern Criminal Investigations." Among the items upon which he touched were ballistics, finger prints, blood and hair identification, and the scientist in the courtroom. Dr. Harrison was introduced by C. C. Crawford, Dean of the School of Engineering.

WESTERN N. Y.—ONTARIO

A small meeting of international flavor was held by members of the Western New York-Ontario District Council in Niagara Falls, Ont., on April 29. Following dinner, the group heard a brief report on the District's activities from Chairman Clarence Lamoreaux.

The speaker for the evening was the Society's President, Dr. Rudolph A. Schatzel, who presented his very interesting talk on insulated wire and cable.

Nuclear Congress Explores Peaceful Uses of Atom

Extraordinary interest by engineers and scientists was evidenced throughout the highly successful 1957 Nuclear Congress held at Philadelphia's Convention Hall, March 10 to 15. More than 8000 engineers, business men, and scientists attended the week-long session coordinated by the Engineers Joint Council and sponsored by 25 engineering and scientific societies, including ASTM. The Congress was devoted to peaceful uses of atomic energy. The program dealt with such topics as reactor design, disposal of radioactive wastes, and use of isotopes in industry.

Copies of the technical papers will be available until Jan. 15, 1958 from the American Society of Mechanical Engineers at 30 cents each. A bound volume of Hot Laboratories papers is available at $10 from the ASME Order Department, 29 West 39th Street, New York 18, N. Y. Transcripts of the Atomic Energy in Industry Conference may be purchased from the National Industrial Conference Board, 460 Park Ave., New York, N. Y

Properties of Cast Iron at Elevated Temperatures

—A PROGRESS REPORT—1957

By J. R. KATTUS[1]

SINCE 1954 a research project to investigate the "Properties of Cast Iron at Elevated Temperatures" has been in progress at Southern Research Institute under the sponsorship of the ASME-ASTM Joint Committee on Effect of Temperature on the Properties of Metals. The objective of this work is to determine the suitability of cast-iron alloys for load-carrying applications in the temperature range 700 to 1000 F.

The project is scheduled for completion in 1958, and a final report should follow reasonably soon after that.

The test results indicate that certain cast-iron alloys are suitable for load-carrying applications at 800 F. At this temperature, no sharp deterioration in creep-rupture properties occurred in exposure times approaching 5000 hr.

The suitability of cast iron for many applications depends upon its ability to withstand thermal shock.

Since the creep-rupture tests indicated that cast-iron alloys are not promising for service at 1000 F, thermal-shock testing was carried out only at 800 F.

In carrying out a test, the specimen was loaded and thermally cycled between 800 and 150 F and the number of cycles to rupture was determined. Both smooth and notched specimens were tested. The notched test was adopted as standard since it was more severe and applicable to all alloys. The smooth nodular-iron specimen never ruptured in thermal shock.

In the accompaning Table, the 10-year rupture strength and thermal-fatigue endurance limit for various alloys at 800 F are compared.

Alloy	10-Year Rupture Strength at 800 F, psi	Thermal-Fatigue Endurance Limit in Tension at 800 F, psi
Chrome-molybdenum gray iron....	30,000	17,500
Molybdenum gray iron............	25,000	15,000
Chrome - nickel-molybdenum vanadium gray iron.	25,000	16,000
Unalloyed ferritic nodular iron....	17,000	27,500
Unalloyed gray iron	15,000	12,500
Nickel-molybdenum gray iron.......	25,000	18,000
Chromium gray iron		12,500

[1] Head, metallurgy section, Southern Research Institute, Birmingham, Ala.

The stresses shown in this table are recommended as the maximum applied tensile stresses for the various alloys in applications involving creep or thermal shock.

Maximum stresses for service applications involving both creep and thermal shock should be based upon the 10-year rupture strength or thermal-fatigue endurance limit, whichever is lower.

Alloying has a marked effect on the creep-rupture properties of cast iron. Among the alloying elements tested, molybdenum is the most potent for improving these properties. The chrome-moly iron had the best properties of all the alloys tested, but chromium additions alone were not beneficial to creep-rupture properties. The chrome-moly iron had creep-rupture properties intermediate to those of a hot-rolled carbon-molybdenum steel and a hot-rolled low-carbon steel. All of the other irons were inferior in creep-rupture properties to the low-carbon steel, although the chrome-nickel- molybdenum - vanadium iron approached it closely. The unalloyed ferritic nodular iron was slightly superior to the unalloyed pearlitic gray iron.

Small additions of molybdenum and nickel improved the thermal-shock resistance of gray iron.

The unalloyed ferritic nodular iron was far superior in therma'-shock resistance to any of the gray irons that were tested.

Shipping Containers

Work on Cushioning Materials Progresses

AT THE April meeting of Committee D-10, held in Chicago, Ill., the results of the second collaborative test program for the establishment of a test for cushioning materials were reviewed. In this program, seven laboratories tested two types of foam and one type of fibrous glass cushioning material with an accelerometer coupled with either a cathode-ray oscilloscope or a galvanometer. The data from these tests have been most encouraging and a new program based on these data will be established.

Four years ago Committee D-10 began work on re-evaluating the drum, drop, and vibration tests. Work in this area is reaching a conclusion—complete revision of the standard method of drop test of shipping containers (D 775) has been approved by the committee and revisions of the drum test and the vibration test are being prepared.

A reawakened interest in the reproducibility of the inclined impact test (D 880) has encouraged the establishment of a new test group to review this method. Work on a method to determine or predict the stacking qualities of containers is continuing. The recently completed collaborative tests on the water vapor permeability of shipping containers has indicated that revisions will be necessary on the Method for Water Vapor Permeability (D 1008).

Adhesives

Meeting at Wright Field Stresses Aircraft Interest in Adhesives

THE highlight of the Committee D-14 meeting held at Wright Air Development Center, Dayton, Ohio, in April, was a visit to the full-scale test laboratories. Here the supersonic B-58 bomber undergoing tests at the Center, was being prepared for structural testing which will be carried in the last phase to the ultimate destruction of the aircraft. This aircraft utilizes structural sandwich construction in all major surface components. In the B-58, adhesives are used more extensively than in any other piloted aircraft.

The committee has long recognized the interest of air-frame manufacturers in adhesives and will establish a subcommittee on aircraft adhesives. At Dayton the committee also established a subcommittee on wood-to-wood adhesives.

The committee heard reports on a large number of projects which are nearing completion. These projects include a new method of peel test using a climbing drum peel tester, a proposed method for the T-peel test, a metal-to-metal creep test which has been used in the aircraft field for several years, the water absorptiveness of paper labels, a specification for adhesives for automatic machine labeling of bottles, and a specification for adhesives for acoustical tile.

The collaborative test program to revise the rates of loading, begun in the Test for Strength Properties of Adhesives in Shear by Tension Loading (D 1002), has completed testing specimens at three loading rates. A decision on the fourth rate of loading speed will be based on the data from the completed tests. This test program is noteworthy in that a most effective means of cutting the tension test strips has been developed.

Mountain Air Sparks Ideas at

The Gordon Research Conferences

NOT AS a vacation, but for strictly business reasons, the week spent in the cool New Hampshire mountains is definitely designed to be one of relaxation for a number of the country's top technical men. This summer trek to New Hampshire has been occurring annually since 1947 for a most serious purpose, for these scientists meet with others from industry, universities, and Government laboratories in this country as well as scientists from abroad while attending one of the Gordon Research Conferences.

The conferences were conceived by the late Dr. Neil E. Gordon, chemistry professor at Johns Hopkins University. In the summer of 1931, at Gibson Island in Chesapeake Bay, he gathered together a number of outstanding chemists for a week-long scientific talkfest. The idea caught on and for the next 15 years the conferences were held at Gibson Island. From a small beginning, a single conference week has grown to 36 weeks of conferences now held at three separate locations in New Hampshire, 12 weeks in each place, running simultaneously.

Subjects Varied

The conferences, with attendance at each limited to about 100 people, bear little resemblance to technical sessions and symposia held at national meetings of technical and professional societies. In contrast to the more or less formal one-way communication of speaker to his audience at a symposium, there is plenty of give and take at the Gordon Conferences. Interruption of the speaker is not unusual, often resulting in a heated exchange on some highly technical point.

While the subject matter usually has some relation to chemistry it actually embraces practically all the sciences. Listed in the box on this page are the subjects covered in each of the 36 weeks this summer.

Discussions Off the Record

Those who have attended the conferences look forward eagerly to the next one, for they know they will meet the leaders in their field and will have the opportunity for an exchange of ideas which they do not have in their comparative isolation back home. These people are working at the frontiers of science, each in an area so specialized that he has little opportunity during the year for a give-and-take discussion with others like himself. Publication of the discussions is definitely taboo, and since this is a recognized policy of the conferences, the conferees feel free to try out their latest theories on their fellow scientists.

Informal Atmosphere

On just any Sunday afternoon during the summer, conferees will be arriving by train, plane, and automobile at one of the three New Hampshire locations—Colby Junior College, New Hampton School, and Kimball Union Academy. These schools, including dormitories and dining facilities, are diverted during the summer from their regular purpose of educating the youngsters. Most conferees bring their sports equipment, including golf bags, tennis rackets, swimming trunks, and hiking and mountain climbing gear. The typical wardrobe includes sport-shirts and shorts.

Conferences are held in the mornings, Monday through Friday, and in the evenings, Monday through Thursday. The afternoons are free for sports or just taking it easy. After the evening session some of the more nocturnal conferees gather in the snack bar or in dormitory rooms, discussing such subjects as chemical reaction kinetics, dislocations in metals, information theory and polymer structure far into the night. The learned bull sessions are not confined to the evening hours. They continue on the golf course, during hikes, and in the sun between dips at any of the many nearby lakes.

Conference Organization

Director of the conferences for the past ten years is Dr. W. George Parks, head of the Chemistry Department at the University of Rhode Island. Dr. Parks modestly describes himself as a catalyst who holds together hundreds of imaginations just long enough to get a reaction. With his colleague, Dr. Alexander Cruickshank, he handles all the administrative details of the conferences.

Since 1937 the conferences have been affiliated with the American Association for the Advancement of Science. Also, a number of industries serve as sponsors. Their representatives, with the conference chairmen, form an administrative council which elects a group of trustees who are responsible for management of the conferences. Last summer the Gordon Research Conferences were

(*Please turn to page 16*)

Conference Topics in 1957

Petroleum
Separation and Purification
Textiles
Instrumentation
Medicinal Chemistry
Food and Nutrition
Chemistry and Physics of Liquids Relaxation Phenomena
Coal
Radiation Chemistry
Microbiological Deterioration
Steroids and Related Natural Products
Inorganic Chemistry
Lipide Metabolism
Nuclear Chemistry
Chemistry and Physics of Metals
Chemistry at Interfaces
Ion Exchange
Organic Coatings
Catalysis
Polymers
Corrosion
Elastomers
Vitamins and Metabolism
Cancer
Metals at High Temperatures
Proteins and Nucleic Acids
Organic Reactions and Processes
Statistics in Chemistry and Chemical Engineering
Analytical Chemistry
Adhesion
Cell Structure and Metabolism
Solid-State Studies in Ceramics
Chemistry, Physiology, and Structure of Bones and Teeth
Biochemistry and Agriculture
Toxicology and Safety Evaluations
Glass

By J. W. CORBETT
Vice President, System Operations
Southern Pacific Co.

Out of Civil War chaos . .

Standardization and Research in the Railroad Industry*

. . . have developed a network of connecting roads functioning as a unit, interchanging equipment, and repairs anywhere on the American continent

YOU HAVE all watched long trains of freight cars passing by at railroad crossings and have noted the ownership medallions and names representing railroads from all parts of the North American continent. We take for granted today the fact that freight can be loaded in a railroad car of any ownership and moved practically anywhere on our continent without transferring the lading. If these cars require repairs en route, they can be quickly returned to service using materials and equipment taken from store stock of the handling railroad and continue on their journey with minimum delay.

This orderly interchange of freight equipment and repairs, now so commonplace, has not always existed. It is the result of standardization made possible by the planning and hard work of generations of railroad men. Probably more than most industries, railroads realize and appreciate the value of standardization. Without it, the free interchange of equipment among competitive railroads would not be possible and the national growth and economy would be retarded. Today we see a network of competitive railroads functioning as a whole, exchanging equipment readily, moving freight rapidly and keeping up with the demands of the national economy.

Early Railroads Not Connected

However, this fortunate situation did not always prevail. Not too long ago, as history goes, the railroads in this country were constructed and developed as individual units with no particular thought of interchanging freight from one road to another. In fact, in the early beginnings of railroading in this country, there were no physical connections between the rails of one road and those of another, and, in many cases, track gages were also different. Each railroad designed and built freight cars to meet its own needs with little or no regard for the designs of cars built by other railroads. Freight equipment operated only on the rails of the owning road. Where freight originated at one location on a railroad and was consigned to a destination on another railroad it was of course necessary to transfer the load when the freight car reached the end of the rails of the originating line. In many instances, this transfer involved hauling the goods for a considerable distance in horse or ox-drawn wagons and delivering them to the closest railhead of the next railroad. The load was again transferred to the cars of the second carrier and this procedure repeated as often as necessary depending on the distance and the number of railroads traversed.

As our country developed and railroad mileages were extended, it was only natural that physical connections were made between certain railroads. These connections permitted the organization of through freight lines which could be operated over the rails of more than one road, and some efforts were made to set up dispatch or "fast freight" lines to expedite movement of traffic without transfer of loads at the junction points. However, the interchange of freight cars to prevent such transferring of loads at terminals was not practiced to any great extent until the fall of 1864 during the Civil War. This unfortunate episode in our history emphasized the shortcomings of a disjointed railroad system and the need for standardization to permit the interchange of freight equipment. The movement of men and supplies during the war was seriously handicapped by the lack of an integrated transportation system.

Civil War Spurs Interchange

As a result of the deplorable experience during the Civil War, railroad management quickly realized the need for standardization. A number of conferences were held during the years

* Presented at the Railroad Luncheon held during the ASTM Second Pacific Area National Meeting in Los Angeles, September, 1956.

1864 to 1866 to consider rules governing the exchange of cars and the adoption of standard designs and practices for the more important components of freight cars which affected interchange and prompt repair. These conferences resulted in the organization of the Master Car Builders' Assn. in 1867.

Obviously, the first task of this group was to inaugurate the establishment of standards for car construction. The problems of standardization were greatly complicated by the fact that each railroad designed and built cars to suit its own individual needs. This meant that there were about as many designs of cars as there were railroads. Wheel diameters varied, height of car floors differed, and there was no uniformity of couplings, brakes, axles, wheels, journals, and other important parts. This absence of uniformity in design of freight cars and component parts resulted in heavy expense to the railroads as well as delays in movement of traffic. When a car broke down en route, it was often necessary to hold it out of service for a long period of time while necessary material for repairs was being obtained from the owner. In many cases freight was delayed or had to be transferred to another car, thereby defeating the purpose of interchange.

Although the path was long and hard and we can imagine the many conflicts and arguments that must have ensued, progress was gradually made in the cooperative groups. Standardization of parts and rules for interchange of equipment became a reality. In addition to the standardization of physical design of freight cars, it was also necessary to formulate a code of rules to govern the interchange of freight cars to insure mutual agreement between railroads on the exchange of equipment. The first code of interchange rules was adopted at St. Louis in June 1872, eighty-four years ago, and consisted of two printed pages and nine rules. Since that time these rules have been revised a number of times to meet changing conditions until today all railroads and private car lines operate under a uniform code of rules which insures the orderly interchange and repair of equipment throughout the North American continent. This accomplishment is truly a tribute to the efforts of many men working toward a common goal of standardization.

Diesel Locomotives Standardized

Standardization of locomotive equipment has not, of course, had the impetus in the past of the work on car equipment operating in interchange. During the era of the steam locomotive which has recently passed, most railroads designed and had steam locomotives built to their own specifications. However, with the advent of dieselization and the passing of the steam locomotive from the American scene, we have witnessed another outstanding example of standardization whereby the diesel locomotive builders have developed standard types of motive power suitable for use on any railroad in the country. This standardization has permitted mass production of replacement parts which has resulted in economies both to the producer and purchaser.

Standardization of Materials and ASTM

Another form of standardization in which railroads are vitally interested is the standardization of materials. As a major purchaser of raw materials and manufactured products, the railroads realize the value and economies available through such standardization. Many railroads have been longtime members of the ASTM and have been represented on the technical committees of the Society in the interest of developing material specifications acceptable equally to the purchaser and consumer. The railroads have benefited by the ASTM standards for many years and have made use of them in their purchases of steels, non-ferrous metals, paints, chemicals, petroleum products, and the wide variety of materials used in the operation of a railroad.

As can be realized, the widespread nature of railroad operations makes it mandatory that common standards be followed at all locations on the railroad. Among such common standards must be the controlled specification and purchasing of materials. Many railroads prepare their own specifications for end use products in which numerous references to ASTM standards are made. Here is where ASTM and the railroads come directly together. The railroads rely on ASTM to keep their standards up to date and functional so that as purchasers, they will be assured of material meeting the latest developments of industry.

The ASTM standards can be likened to the code of interchange rules for freight equipment to which I have previously referred. In the case of the interchange rules, we have an understanding among various railroads on acceptable standards for equipment. In the ASTM specifications we have a code of acceptable standards for materials. The use of ASTM specifications insures that both the purchaser and the supplier understand the quality requirements mutually desired. If we did not have the ASTM standards, it is easy to imagine the wide variation and chaotic condition that would exist in the specification and purchase of materials. This condition would be similar to the disorder that existed during the pre-Civil War days in railroading. As a representative of railroad management, I should like to commend the American Society for Testing Materials on its excellent work in the field of materials of engineering and the standardization of specifications and methods of testing. The Southern Pacific Co. has been a member of the Society for fifty years and has valued its long association and the mutual benefits derived therefrom.

Railroad Research Expanding

Some people believe the railroad industry to be moribund, but I am sure that recent developments should convince these people otherwise. The railroads are a dynamic industry constantly looking for better ways of doing things. There is a continual search for methods of reducing operating expenses in the face of increasing costs. Adequate research in the railroad industry, as in industry in general, is insurance against the future. We can never be satisfied with the present methods of conducting our business but must always be ready to accept the improvements and developments of our ever-changing technology so that we can benefit to the utmost from the new tools and techniques placed at our disposal.

Electronics Opens Doors

As an illustration, the field of electronics has opened new doors to the railroads. Modern radio communication has greatly improved railroad operation. Today it is possible for the engineer to talk directly to the conductor in the caboose on our freight trains as well as to communicate with the dispatcher or other operating personnel concerned with the movement of the train. In our mountain districts where helper engines are used the engineer on the head end can talk directly to the engineer on the helper engine and coordinate movements of the train instantaneously. Similar means of communication from automotive equipment or in train yards have improved our operation. Some of our passenger trains have commercial radio-telephones for use by our patrons. We have conducted experiments with television in yards, freight stations, and at icing stations. Radar is used to measure the speed of freight cars as they roll down inclines in gravity yards. Microwave transmitters, reflectors, and receivers are being installed in the neighborhood of Mt.

Shasta to bridge an area where wire lines are sometimes disabled by storms.

Electronics are also used in our office procedures for sorting, data processing, payrolls, and statistical work. Electronic accounting machines using magnetic memory storage, handle the tremendous work load of data processing at our General Office. We are even installing electronic elevators at our headquarters to provide more efficient operation.

In the field of research and testing on our railroad, we also employ the latest type of electronic equipment. Comparator densitometers are used in connection with our spectrographic analyses to determine quantitatively the amounts of various elements present in samples. Ultrasonic reflectoscopes are used to project a high-frequency wave through wheels and axles and other parts to locate hidden defects. An electron microscope is used at our general laboratory to assist us in our research work on fuels and lubricants. Our detector cars in rail testing equipment employ electronics to search for flaws in track.

A product of the atomic energy development is our use of the radioactive isotope cobalt 60 at our Sacramento research laboratory. This material permits us to locate flaws and defects in large castings such as couplers and draft gear parts.

In the field of mechanical research we are developing practical means for utilizing lower cost fuels in our diesel locomotives, such as the dual fuel system being tried out over the Sierra in our freight locomotives. This effort is spurred by increasing fuel costs, which represent the major portion of operating expense of a diesel engine, in addition to the future prospects for obtaining adequate quantities of distillate fuel. This is a cooperative effort between the railroads and the oil companies on the West Coast. If, as a major consumer of fuels, the railroads can find ways and means to utilize less critical fuels in their diesel locomotives, both they and the oil companies will benefit. The production problems of the oil companies will be alleviated and the cost of fuels for diesel locomotives will be reduced, not to mention the advantage of releasing large quantities of distillate fuel for the Armed Forces in the event of a national emergency.

Efforts to Reduce Lading Damage

We are also actively engaged in other mechanical research projects, one of which is of particular interest. This is our investigation of an improved cushioning mechanism for freight car use. The cost of lading damage on railroads in general, particularly under modern high-speed movement of freight, is inordinately high. The Southern Pacific engaged Stanford Research Inst. to work with our research engineers to develop a better method for protecting both cars and lading by means of an improved cushioning arrangement behind the couplers. The usual design of freight car has what is known as a draft gear behind the coupler to act as a shock absorber for the protection of car structure and contents. The standard draft gear is limited in the amount of shock it can absorb. To develop a cushioning device with higher shock absorption capacity, our research team developed what we call the "hydracushion underframe." This underframe consists of a sliding sill extending the full length of the car with coupler at each end. At the mid-point of this sliding sill is a stack of friction plates which are alternately secured to the sliding sill and to the fixed frame in a sandwich construction. Under this stack of plates is a hydraulic actuating cylinder containing a piston which pushes against the bottom of the stack of plates. The amount of force exerted by this piston is determined by the magnitude of displacement of the sliding sill. In other words, the harder the sill is struck the greater is the braking pressure exerted by the hydraulic piston against the friction plates.

Our preliminary experience with this design of cushion underframe, both by instrumented impact tests and in actual service handling commodities with high lading damage index, has been most satisfactory and we plan to construct 350 50-ft box cars with this device.

Another project of interest is the development of an improved method of preventing wheel slip on our locomotives. Since the inception of steam locomotives, the standard method of preventing wheel slip or improving traction has been to spray sand in the wheel-rail contact area. While this time-proven method for improving adhesion has been effective, it has certain serious drawbacks. The cost of purchasing and handling sand in the large quantities necessary is substantial, but probably the most serious objection is the damage caused by the sand and silica dust infiltrating the ballast on our mountain grades. This results in the frequent removal and cleaning of ballast to avoid damage to track structure. We are currently conducting an active research program to find an improved method for accomplishing wheel slip control without the undesirable effects. The use of adhesion shoes which condition the wheel tread and apply the anti-lubricant at the same time may be the solution to this problem. We are currently experimenting with this device on one of our mountain diesel freight units.

These are only a fraction of the many interesting phases of research and standardization in railroading. Efficient as they already are, the railroads are still being revolutionized by continuing research. In their finding still better ways to serve the public lies the assurance of increasing financial strength for the railroad industry to counteract increasing costs, taxes, and competition

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Gordon Conference

(Continued from page 13)

incorporated in New Hampshire as a nonprofit educational endeavor, thus enabling them to receive contributions to aid certain participants who might not otherwise be able to attend. This group may include scientists from abroad or those from universities operating on a limited budget.

While anyone may apply to attend, only those who are able to contribute to the discussions are invited. Also, the number of participants at an individual conference is limited. An isolated location was deliberately chosen. While the New Hampshire mountains may be hard to reach, the area does provide a relaxing atmosphere that is hard to find in any of the large centers of population.

Among the participants every year will be found many individuals who have presented papers at ASTM meetings or who are active on ASTM technical committees. While the emphasis at the conferences is on fundamental science, the various industry sponsors know that many of their past and current developments are based on once obscure theories first expounded at these conferences. Many matters being discussed at the 1957 conferences will provide subjects for ASTM standardization in years to come.

ASTM STANDARDS APPROVED BY ASA AS AMERICAN STANDARD

Textiles (Approved April 3, 1957)

- Definition of Terms Relating to Textile Materials (ASTM D 123 – 55; ASA L14.12-1957)
- Specifications and Methods of Test for Fineness of Wool Tops (ASTM D 472 – 56; ZSA L14.29-1957)
- Specifications and Methods of Test for Fineness of Wool (ASTM D 419 – 55 T; ASA L14.26-1957)
- Method of Test for Fiber Length of Wool Tops (ASTM D 519 – 55 T; ASA L14.32-1957)

Random Samples...

FROM THE CURRENT MATERIALS NEWS

From the broad stream of current materials information flowing from "in-box" to "out-box" in a busy editorial office, random samples (mostly random) have been plucked. Thinking them worth re-showing to ASTM'ers who may have missed the original articles, we have included them here. Of course, we had to trim the samples to fit. There will be those who are not satisfied with samples, especially ones which are not really random. But these ASTM'ers can contact the institution, magazine, governmental agency, etc., who placed the original information in the stream, or address Random Samples, ASTM, 1916 Race St., Philadelphia 3, Pa.

Heat Barrier Bounced

WESTINGHOUSE scientists have developed a new high-strength, high-temperature metal which is designed to help push back the "heat barrier" now being encountered by jet engines in the nation's new supersonic aircraft.

Impact heating is now a major consideration in the design of the inlet and compressor of modern jet engines. By using titanium for those parts that were formerly made of aluminum, magnesium, and low-alloy stainless steels, engineers can protect these sections of the engine from the effects of impact heating without sacrificing the turbojet's light weight advantage.

However, back in the turbine section of the engine exists what might be called a second "heat barrier" which is proving to be a much more difficult problem for the turbojet designer. A jet engine gets its energy for propulsion by increasing the temperature of the air passing through it. As a general rule, the greater the increase in air temperature, the more thrust a given engine will produce and the faster the airplane will fly. If the speeds of new fighters, bombers, and missiles are to continue up the supersonic scale, their engines must be able to run at higher and higher temperatures and they must do this without having any of their components suffer significant losses in mechanical strength. The new Westinghouse metal is intended as a structural material for use in the turbine section of the jet engine, where the hottest moving parts are found. It offers special promise as a material for constructing turbine disks.

A jet engine turbine disk is a metal wheel that is bolted to the aft end of the rotating shaft of the engine. Anchored to its outer rim are some 50 or more turbine blades. White-hot gases from the burning fuel push against the blades and spin the disk and shaft at speeds up to 20,000 rpm. The disk, whirling at red-hot temperatures, undergoes stresses as great as 50,000 psi.

The metal already has progressed to the point where 3500-lb ingots have been prepared on a pilot plant scale at Westinghouse's new metals manufacturing plant at Blairsville, Pa. The new material, which is referred to simply as W545, is an alloy of six essential elements: iron, nickel, chromium, and in smaller proportions, molybdenum, titanium, and boron. Increasing the operating strength at temperature of a high-temperature alloy can be done by adding greater quantities of these ingredients which cause hardening in the alloy. However, this procedure usually results in a loss of ductility, causing the alloy to become brittle and more susceptible to fracture. This low ductility starts to grow during the hardening process when imperfections and dislocations of the atoms occur along the individual grain boundaries of the alloy. It appeared likely that one solution to the problem might be to fill up these spider-web lines of brittleness to make the precipitation reaction more generalized within the grains rather than concentrated at the boundaries. This called for an element whose atom was of such a size that it would not merely move in and be a substitute in the alloy lattice for one of the iron, cobalt, nickel or chromium atoms, which are all about identical in size. It would also have to be a larger atom than carbon, nitrogen, or oxygen which can actually slip inside the crystal lattice of the alloy. The element boron filled the bill. Approximately $\frac{3}{4}$ the size of the iron atom, it is too small to be a substitutional-type atom and too large to be the interstitial type.

Basically, W545 is a modified version of Discaloy, a high-temperature alloy first developed at the Westinghouse Research Laboratory some ten years ago, and an outstanding turbine disk material in its own right.

Tests show W545 to be an outstanding high-strength, high-temperature alloy. When heated to a temperature of 1200 F and subjected to a stress of 75,000 psi, the W545 test specimens withstood these conditions for as much as 300 hr without breaking. Under equivalent conditions, standard turbine disk materials would probably have a lifetime of less than 10 hr.

GE Whiz

MAGNETS are increasingly important in our mechanized and instrument-controlled lives. In this country alone, more than 50 million magnets are produced and used each year; it takes over 200 magnets to keep the instruments of a bomber functioning faithfully. Permanent magnets, that is, those not requiring an electrical current to make them work, are of particular industrial importance, and any improvement in them that permits smaller, lighter, more easily shaped units is significant. The annual citation of the Industrial Science Section of the AAAS, presented last December to the General Electric Instrument Department, recognized such an achievement—a fine-particle iron magnet.

The reason why magnets are magnetic is related to their inner structure. Like all matter, they are composed of atoms, with electrons revolving about the atomic nuclei. But each electron rotates too, and with the electron-spin there is associated a magnetic field, pointing in a given direction. Normally, about as many electrons spin in one direction as another, so that the magnetic fields cancel out. But in a few elements, and iron is one, there is no such balance, and a net magnetic field is associated with each atom. When such atoms form a solid crystal, the electron-spins of adjacent atoms may interact so that the magnetic field of each atom is closely parallel to that of its neighbors, producing a region, or "domain" in which all the atoms are in magnetic alignment. But these magnetic domains are small, any piece of iron of useful size will contain many of them, each with its magnetic field pointing in a different direction.

To produce a magnet, it is necessary to apply a powerful external magnetic field, as induced for example by an electrical current; the domain boundaries will then shift, and all the domains will tend to line up with the applied field. In some materials, the domain boundaries will move easily, but will then shift back to their random orientation almost as soon as the external field is removed. Magnetic materials of this type have

their valuable place in electrical apparatus such as transformers. But many instruments for measurement and control require permanent magnets, which resist demagnetization almost indefinitely.

Domain boundaries are clearly the key to making permanent magnets. Thomas O. Paine of General Electric and his colleagues, Lewis I. Mendelsohn and Fred E. Luborsky, experimented with iron particles smaller than a domain boundary—one-millionth of an inch—that contained no boundary to move, and therefore could not be readily demagnetized. Such particles can only change the direction of their magnetic field if all their constituent atoms change their direction of magnetization simultaneously, and this would be difficult to do with any material held together by strong crystal forces. Unfortunately, iron, which is a good magnetic material, does not have this strong crystal structure, so that a further step had to be taken.

After several years of research, Dr. Paine and his colleagues discovered that highly elongated iron particles of submicroscopic size do have the necessary properties. It takes an unusually high magnetic field, applied in just the right way, to demagnetize elongated particles; the particles have, in other words, an unexpectedly high resistance to demagnetization. A magnet made of such particles has the same structure as an iron magnet, but resists demagnetization 100,000 times more vigorously.

Before they can be used in a magnet, the elongated iron particles are aligned by a magnetic field and compacted under great pressure with a binder that can be one of a variety of materials. Metal, plastics, glass, or rubber will serve equally well, and the resulting permanent magnet can be easily machined, drilled, molded, or soldered to fit the occasion. The GE experiments thus give future promise that manufacturers will be able to design smaller, lighter, more accurate, and more rugged instruments, with greater adaptability to industrial uses.

Industrial Bulletin, Arthur D. Little, Inc., February, 1957.

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About E.T.D. Steel

By the name "Fatigue Proof" a carbon steel bar product is offered commercially which has guaranteed Rockwell C values of 30, a tensile strength of 140,000 psi, and a yield strength of 125,000 psi. This material machines about 25 per cent faster than annealed alloy steel and as much as 100 per cent faster than alloy steel heat treated to the same strength level. Inherent in the manufacturing procedure is a uniformity of property from heat to heat, bar to bar, and across the diameter of the bar which has not been available in quenched and tempered bar stock. Its improved fatigue strength has been proved by actual test.

The properties depend upon: first, careful selection of a particular material composition of steel; second, the control of the amount of deformation by reduction; third, the temperature at which deformation is carried out to bring about metallurgical changes which result in a new combination of physical and mechanical properties.

This is an exclusive development of La Salle Steel Co. Four United States patents were granted October 23, 1956, covering this invention. Other United States and foreign patents and patent applications also describe this process.

The process entails strain hardening by slip mechanism, age or precipitation hardening, and in all probability the formation of a substructure within the grains from the deformation at elevated temperatures.

The "E.T.D." process holds promise of bringing about the following:

1. The lessening of the dependence on strategically scarce alloys.
2. The making possible of combinations of properties not economically attainable by present methods.
3. In many cases the elimination of heat treatment and subsequent operations.
4. The combination of high strength with improved machinability.
5. The direct production by machining operations only of parts which have before required multiple and often costly operations.

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Vulcan's Answer

Atomic energy has been successfully used to vulcanize an automobile tire, The B. F. Goodrich Co. announced in Akron, Ohio, recently. The company's scientists said they believe the tire is the first large commercial item ever processed by nuclear radiation and the first basic change in the "curing" of rubber products since the discovery of vulcanization in 1839. In addition to proving the practicability of vulcanizing large items by nuclear radiation, the experiment produced a tire expected to wear longer and resist deterioration better than conventionally vulcanized tires.

Vulcanization normally involves adding sulfur and other chemicals to rubber and heating it. Until it is vulcanized, rubber is a relatively useless material, sticky in hot weather, brittle in cold, and susceptible to rapid deterioration. Nuclear vulcanization of the tire was achieved without the use of heat and no sulfur nor accelerators, standard components of all of today's vulcanization processes, were used. The nuclear vulcanization resulted in a direct linkage of the carbon atom chains of the rubber molecules. Ordinarily, the carbon atom chains are linked through sulfur atoms, and this is the "weak link" in vulcanized rubber.

Tests show the nuclear vulcanized tire to have considerably better resistance to aging and deterioration than conventionally vulcanized tires while the tread shows "above normal" resistance to abrasion and wear. The company said the achievement proved that in the future, if nuclear energy becomes economically practical, tires could be vulcanized "cold" on a production basis much more rapidly than they are with today's processes which require temperatures above 300 F.

The vulcanization was achieved by B. F. Goodrich scientists at the Atomic Energy Commission's National Reactor Testing Station in Idaho. The tire, in a steel mold, was vulcanized by rotating it slowly over radioactive fuel elements taken from a nuclear reactor. This was done in a 17-ft deep water-filled canal at the Materials Testing Reactor Gamma Facility, the water protecting the scientists from exposure to radiation.

In commercial production in the future, vulcanization could be done in a well with radiation being supplied by machines, or by radioactive by-products from a nuclear reactor, similar to those in the fuel elements used in the Gamma Facility. Commercial development of this and similar processes will turn to practical use these radioactive wastes, the disposal of which is today an important problem in the development of economic atomic power.

Triennial Inspection Scheduled by NACA

The Triennial Inspection of the NACA Lewis Flight Propulsion Laboratory will be held next Oct. 7, 8, 9 and 10, 1957. Identical programs will be given on each of the four days at the Laboratory in Cleveland, Ohio, by scientists of the National Advisory Committee for Aeronautics.

Inspections in recent years have been held in the spring but are now being scheduled in the fall. Dr. John F. Victory, NACA Executive Secretary, said the fall timing is believed more convenient for NACA's guests. Invitations will be issued in August to interested persons in the aviation industry, the armed services and other branches of Government, and the general public.

Wood Poles for Communication Lines[*]

By GEORGE Q. LUMSDEN

200 to 250 million wood poles have been produced in the U. S. since Morse ordered the first 700 in 1844. Why have they outlived all their proposed substitutes and how can they be improved?

THE WOOD pole has served the communications industries with distinction since that day in February, 1844, when Samuel F. B. Morse ordered 700 straight and sound chestnut "posts" for constructing, between Baltimore and Washington, what was to be the first pole line. The telephone and telegraph as well as the power and light utilities realized at an early date that the use of poles in overhead transmission was highly economical, and it is estimated that between 200 million and 250 million wood poles have been produced for use in the United States alone. Today there are some 85 to 100 million poles standing in the lines of the Bell System and independent telephone companies, power and light companies, R.E.A., and the railroad and telegraph companies. Assuming an average volume of 10 cu ft, this represents one billion cu ft of wood, or putting it in lumbermen's terms, twelve billion board feet. The wood pole has many advantages over its competitors; it, like all manufactured products, has some qualities that can be bettered. It is proposed in this paper to discuss the good features of the modern pole as well as to point out areas in which further improvements can be made in order to increase its long-term usefulness to the public utilities. Possibly, it is an anachronism to discuss such a subject 112 years after the first wood poles were placed in the ground. However, to keep faith, an endeavor will be made to point up ways and means of improving this familiar piece of outside plant construction.

What Is a Wood Pole?

Most laymen do not appreciate what goes into the production of a modern, clean, durable pole. Nature, of course, assumes the primary role. She alone creates this sturdy column of cellulose and lignin. But not all trees make poles. Only those sticks of timber that are straight-grained and free from certain defects are ever brought to the pole producer's plant. People intimate with pole production and consumption know that the requirements of most utility specifications for poles adhere closely to those of the American Standard Specification for Wood Poles, 05.1–1948. This is particularly true of the dimensional requirements—strength requirements—because the pole user is required to conform to the practices stipulated in the National Electrical Safety Code. The Code has approved the present American Standard fiber stress ratings for several species of pole timbers. Public utility commissions generally use the Code as their basis for decision as to the acceptability of pole structures. Therefore, by an "approved" species, it is meant that this particular kind of pole is acceptable under the Code for use by the telephone companies in their own lines or in jointly occupied lines with the light and power utilities.

The current strength ratings are the product of many hundreds of individual tests conducted over the years by the U. S. Forest Service, the Bell System, several universities, and the power and light companies. During the period from 1930 to 1948, a great effort was made to bring the strength ratings for the several species into a uniform pattern so as to facilitate the design engineer's work. For example, prior to 1930, a class A pole of cedar bore no strength relationship to a class A of southern pine. The new classification system was singularly successful in establishing the strength relationships on a common ground, when through the American Standards, the "letter" classification system was discarded and the numerical classification was introduced. Under the "numerical" system, poles of the same class were rated as of the same strength regardless of species. This was done by altering the dimensions for each species based on their accepted ultimate fiber stresses. This effort culminated in American Standard 05.1-1948 (**1**).[1] Currently, a study is being undertaken under the auspices of ASTM to obtain more information on fiber stresses and particularly on the interrelation of fiber stresses on the poles of the five most important species (**2,5**). More will be said about this program.

Prior to assignment of a specific class and length, the pole has been run through a shaving machine where planer knives have removed all outer and inner bark and the knots have been trimmed flush. Depending on the species, the poles may then be stacked for air-seasoning from several weeks up to a year so as to render them better fit for uniform treatment. Southern

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NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

* Presented at the Second Pacific Area National Meeting of the Society, Los Angeles, Calif., September 17–21, 1956.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

pine poles are generally treated green but are given a steam conditioning just prior to treatment. After seasoning and in any event before treatment, the poles are roofed and gained in accordance with the consumer's specifications. They then are examined for conformance to the several "material" requirements of the consumer specifications. The reasons for specific limitations and prohibitions are self-evident. A pole with excessive sweep would be unsightly and difficult to climb; a pole with excessive twist grain might cause a rotation of the crossarms during wet and dry seasons, tightening the wires on one side and loosening them on the other; if the knots are oversize and in a critical location, the pole will be weakened; if compression wood is present in the outer annual rings the pole may present a potential climbing hazard; scars are prohibited in the ground line section particularly because it has been found difficult to force preservative into the resinous areas associated with scars; large checks, shakes and splits can be likely sources of loosened line hardware and can cause "cut-outs" of the lineman's climber spurs; decayed poles are not accepted because a pole showing decay at the outset can hardly be expected to give a satisfactory physical life in line; and finally, broken or cracked poles are unserviceable. Strict attention is paid to the branding at 10 ft from the butt because the information contained therein has been found to be of very definite value to the consumer as far as long-lasting identity of the individual pole is concerned.

Application of quality control methods by the producer during the whole manufacturing process generally results in a better, more uniform product. However, the consumer's inspection covering the material requirements of the specification takes place usually immediately before making up the loads for treatment. During 1955 the Western Electric inspectors, who examine the poles intended for Bell System use, reported the causes for their rejections percentage-wise on southern pine poles as shown in Table I. It should be pointed out that the 3.13 per cent over-all rejection is considered a low rate for a material produced by nature. The high quality of poles being manufactured today is the result of the combined efforts of the producer and the consumer's inspector to adhere to the well established and universally accepted American Standard.

Perhaps this explanation of how a specification wood pole is produced is an over-simplification. It is obvious, however, that the pole is not just a stick of wood holding up wires or cable. It has required years of engineering experience and construction "know-how" as well as a lot of man-hours of effort and a lot of money to produce 6,000,000 high-quality poles annually.

Poles of such naturally durable woods as northern white cedar and chestnut either have come into very short supply or, through disease, have been eliminated completely from the pole market. Western red cedar is feeling the pinch.

TABLE I.—CAUSES FOR REJECTION OF SOUTHERN PINE POLES FOR MATERIAL DEFECTS [BEFORE TREATMENT]—1955.

Data through the courtesy of the Supplies Inspection Organization, Western Electric Co., Inc.

Cause	Per cent
Poor trimming	0.57
Over size knots	0.41
Size	0.31
Decay	0.24
Excess sweep or crook	0.21
Compression wood	0.20
Improper butt marking	0.20
Improper 10-ft brand	0.18
Scars	0.18
Improper framing	0.16
Excess limited sweep	0.16
Slabs	0.07
Bark inclusions	0.06
Spurs	0.05
Through-checks, splits, and shakes	0.04
Broken or cracked	0.03
Insect damage	0.03
Twist grain	0.02
Excessive machine shaving	0.01
Total	3.13

TABLE II.—POLE USAGE BY THE BELL SYSTEM, 1955, BY SPECIES AND PRESERVATIVE.

Species	Preservative	Per cent of Input
Southern pine	Creosote Penta-petroleum	80.7
Douglas fir	Penta-petroleum Creosote-penta-petroleum Chemonite	6.9
Lodgepole pine	Penta-petroleum	5.5
Western larch	Penta-petroleum	2.9
Western red cedar	Penta-petroleum	2.7
Northern white cedar	Creosote Penta-petroleum	1.0
Ponderosa pine	Creosote	0.2
Jack and red pine	Creosote	0.1
		100.0

This valuable timber is becoming less and less available because of inaccessibility, and other species such as western larch and inland Douglas fir are being produced in increasing quantities by the cedar pole suppliers. Southern pine and Douglas fir poles are carrying the brunt of the demand together with lodgepole pine. However, this latter species is available only in the lengths up to 35 and sometimes 40 ft. The poles made from these three species have relatively thick, nondurable sapwoods—southern pine averages 3.16 in.,—and it is important therefore that they be well treated with preservatives of unquestionable quality to make them last in line for 35 years or more.

Southern pine and most Douglas fir and lodgepole pine poles are pressure treated. Western red cedar poles and those of other western species are preserved by nonpressure process under strict penetration and retention requirements. The majority of the poles for Bell System use (Table II) are treated by the Rueping empty-cell process with either a low-residue coal-tar creosote or with a suitable petroleum carrier containing approximately 5 per cent pentachlorophenol. Not less than 8 lb of creosote per cubic foot of wood by gage is specified for southern pine, while with pentachlorophenol-petroleum solution, the retention is required to be not less than 0.3 lb of "dry" penta per cubic foot as determined by analysis of a composite sample of increment core borings taken from the second ½-in.—that is, from 0.5 to 1.0 in. in from the surface—of representative poles.

The data in Table II when compared with the information shown in Fig. 1 serve to emphasize the current and future importance of pine poles in the System pole plant. The prospect of any general timber shortage has decreased sharply since the release of the recent timber survey reports of the Forest Service (**3**) and the Stanford Research Inst. (**4**). Presumably some of the optimism may be shared by wood pole producers and consumers. There is no reason to doubt, through the efforts of the Forest Service and others interested in forestry, that more timber will be available for the pole consumer as well as for the general lumber market. In southern pine, however, competition from the pulp and paper industry and in Douglas fir from the plywood industry probably will increase.

Advantages of the Wood Pole

The wood pole is accepted as a highly satisfactory piece of outside plant structure. It has the following advantages:

1. It is available on a country-wide basis at a very low cost compared with its competitors.
2. Attachments are made with simplicity, in fact, a brace and bit only are required, or drive screws may be used.
3. It may be climbed readily by use of standard lineman's climbers.
4. Its electrical resistance is high.
5. It has a long physical life.
6. When it has completed its useful life, it may be disposed of readily.

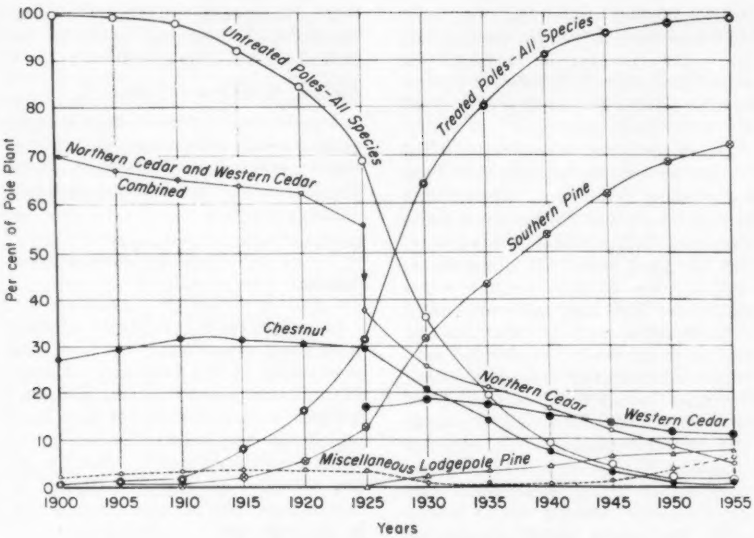

Fig. 1.—Changing Pole Plant—Bell System.

Possible Areas for Improvement of Wood Poles

It goes without saying that any product can be improved. Representing a research and development organization one would be remiss if the shortcomings of this or any other material used so extensively were not constantly analyzed so that the product can be bettered. In the spirit of constructive criticism improvements are suggested in the following areas:

The Pole Prior to Treatment

Reappraisal of Ultimate Fiber Stress Value for All Species

This subject is slated for review by the Sectional Committee 05 on Wood Poles functioning under the American Standards Assn., as soon as the ASTM Pole Research Program (**5**) is completed and the data are available. The ASTM Program costing some $254,000 will be the first all-embracing study made on the five most important pole species in use in the United States—southern pine, western red cedar, Douglas fir, lodgepole pine, and western larch. The results of this program are expected to provide a better understanding of the relative strength of the pole species as well as furnish a more rational basis for safe pole line design. After review and reconsideration of fiber stress ratings, it is expected that American Standard 05.1-1948 will be revised, if warranted, and that the National Electrical Safety Code body will consider any recommendations made.

Uniform Gaining and Roofing Practices

Despite considerable effort in the 1930's to standardize sizes and kinds of gains (mortise, dishout, and slab) and types of roofs (flat top, single-cut slant, and double cut) little progress has been made. The pole producer has felt that this is a problem the pole consumer can solve best. The Bell System has standardized on the slab gain and the flat roof for southern pine poles, but there has been a reluctance on the part of both producer and consumer of poles of other species to swing to this efficient and highly successful method of framing. Currently, a committee of the Edison Electric Inst. is studying the gaining and roofing problem, and it is hoped that their findings will be of value in effecting more uniform gaining procedures. Obviously, economies should result if some agreement can be reached.

Breaking Away of Wood at Knot Clusters in Machine-Shaved Poles

This phenomenon is not uncommon in the top sections of the longer southern pine poles where groups of large knots may occur, Fig. 2. Some believe that this splitting is the result of excessive machine shaving. Unfortunately, the breaking away is not detectable until some time after treatment when the outer fibers of the pole have dried to below the fiber saturation point (28 to 30 per cent moisture). Possibly the remedy lies either in shaving with extreme care or in lifting the planer knives in those knotty areas that are known by experience to produce fiber breaks. Possibly the answer lies in the use of controlled drying methods.

Fig. 2.—Breaking Away of Wood at Knot Clusters in Machine-Shaved Poles.
Note exposure of grain around knot areas and associated checking.

Artificial Drying Methods

The wood pole is heavy compared to most of its competitors. This is particularly true of a green southern pine, in which case a class 5, 35 ft pole will weigh on the average 770 lb. The equivalent fiber glass pole weighs approximately 200 lb and can be carried by two men. Poles of the western species, for the most part air-seasoned, weigh somewhat less than southern pine. Poles may be dried rapidly by artificial means. A charge of green southern pine poles having an average mid-point diameter of 8 in. can be vapor-dried in 10 to 12 hr from 90 per cent moisture down to 35 per cent (**6**). This represents a drop in weight of 18.5 lb per cu ft or in the average pole a decrease of about 185 lb. Within the past three years methods for drying of poles in long "tunnels" or boxes have been described (**7**) and several drying units are in operation in the South and West. With this type of drying it has been found possible to reduce the weight on the average of 15 to 20 lb per cu ft for a class 5, 35 ft southern pine pole on a 8-day drying schedule. This represents a drying from 100 per cent moisture, dry-weight basis, to 35 per cent.

Artificial drying methods are being used with the western species at least at one plant where claims are made that the poles are much freer from injurious checks than are air-dried poles of the same species. A few plants on the West Coast are using modified full-length incising techniques to promote the development of minute slits and reduce occurrence of major checks. Well controlled artificial drying could not only save the pole consumer thousands of dollars per year in freight but might also help overcome the objections, particularly in the East, to poles that check severely.

The Pole During Treatment

Rational Make-up of Treatment Charges

It is a common occurrence to see large poles and small poles, and poles ranging from green to dry, treated in the same charge. In field studies made on some 900 poles by Bell Laboratories it was found that retentions of individual poles in 8 charges averaging 8.8 lb by gage ranged on a gain-in-weight basis, from 2.0 lb to 13.7 lb per cu ft. Twenty-eight per cent of the poles were found to have retained 5.0 lb per cu ft or less. Southern pine poles with such low retentions are "risk" poles. Admittedly, some of this wide discrepancy can be attributed to uncontrollable variations in density of the wood—which affects retention—but most of the difficulty is due to variation in size (**8,9**) and in moisture content of the individual poles in a charge. Some of the trouble may arise from the fact that the plant operator is treating "on order," and there is insufficient elasticity in scheduling to permit him to treat on a more ideal basis.

Proper grouping of poles according to size or volume will shorten both conditioning (steaming, Boultonizing heating in oil) and impregnation times because of the hours saved when dealing with the small poles. It is the customary practice of most treaters, when small poles and large poles are mixed in the same charge, to condition and treat so as to obtain the specified penetration and retention in the large poles. This often means that the small poles are oversteamed. Therefore, the small poles would benefit from a strength standpoint if they were treated separately under lighter schedules. The large poles if treated alone would benefit too insofar as distribution of preservative and penetration is concerned. There would be little, if any, "robbing of oil" generally attributed to the smaller, drier poles in mixed charges.

The Pole After Treatment

Improvements in Cleanliness

Further improvement can be hoped for and expected in cleanliness. In southern pine poles the use of low-residue creosotes at the 8-lb per cu ft level has resulted for the most part in highly acceptable material to the telephone company user. This is not the case with Douglas fir or with lodgepole, red, and jack pine poles. There has been a drifting away from the almost exclusive use of creosote prior to World War II to pentachlorophenol-petroleum solutions (Table II). Possibly work currently under way by several of the tar distilling companies will be fruitful and creosote for use with these latter species will be made available ultimately.

A few consumer complaints have been made on carload lots of penta-petroleum poles. Petroleums of the type used in wood preservation are, of course, less viscous and have a lower surface tension than creosote and therefore tend to exude rapidly if the outer fibers of the wood are overloaded with preservative (**10**). Penta-petroleum bleeding has on the other hand terminated within a few days after treatment and the poles were dry by the time they were set in the ground. Localized bleeding, within 1 to 2 ft of the groundline, has continued on some poles for several months, however. This particular problem may be solved, it is felt, after more study of the characteristics of the petroleums in use today. Perhaps it will be possible to specify petroleum carriers that are truly nonbleeding or that evaporate rapidly to a point at or below the critical nonbleeding retention (**11**).

Fortified Wood Preservatives

Durable poles require that an adequate amount of a permanent preservative be injected deeply into the fibers. The Bell System has four standard pole preservatives:

Oil-Type	(a) Coal tar creosote (b) Pentachlorophenol-petroleum
Salt-type	(c) Greensalt (d) Chemonite

Greensalt (**12,13**), a highly effective clean wood preservative, has been used successfully in the treatment of some 46,000 air-seasoned southern, jack, and red pine poles but does not lend itself readily to the production of green, steam-conditioned poles. Because of the necessity of some air-drying, it cannot compete with creosote or penta in the high-speed production of poles today. In addition air-seasoning means added inventory costs.

Chemonite (**14**) has found considerable favor on the West Coast in the clean treatment of Douglas fir poles. Production continues in line with the telephone companies' demands.

The use of salt-type preservatives often raises the question of a possible reduction in electrical resistance of the treated pole, but it has been found with salt preservatives such as greensalt and chemonite, which stabilize in the wood, that the preservative used is of minor importance. The amount of water present in the wood fibers through lack of seasoning or from rain is by far the most important factor influencing electrical resistance.

It is apparent that of the four standard preservatives, the two oil-type preservatives play a major role. Creosote has been used for well over a century and pentachlorophenol is generally accepted as a highly effective pole preservative today (AWPA Standards P8 and C4). In order to reduce the bleeding tendencies inherent in overloading the fibers of the wood and yet to prevent early decay because of lowered retentions on the outside of the pole, Bell Laboratories have been studying with a great deal of interest the possibilities of combining these two effective wood preservatives. Exhaustive laboratory soil-block bioassay (**15**), test plot and line tests are being performed on a preservative combination of creosote and pentachlorophenol. One plant in Jacksonville, Fla., has been treating poles since late 1953 with a coal-tar creosote-penta solution, 2 per cent penta by weight, and the results have been highly gratifying. A combination of these preservatives results in a very effective, nonbleeding

preservative that easily controls *Lentinus lepideus*, Madison 534, which at present is our most common pole destroying fungus. In recent preliminary work done in cooperation with the Forest Products Laboratory, it has been found that *Lentinus lepideus* is responsible for 42 per cent of the decay in southern pine poles in line. Using the creosote-penta combination, the threshold for *Lentinus* (the retention needed to prevent attack) is lowered on the average from 6 or more lb for straight creosote to 2–4 lb per cu ft for the mixture. The fortified preservative also seems to be more effective against a wider range of organisms than either penta or creosote alone, providing a "shot-gun" pattern against several fungi, a principle heretofore not recognized.

Creosote is in many ways superior to petroleum because of its much higher penta solubility. The solubility of penta in a good petroleum runs from 10 to 15 per cent whereas its solubility in creosote exceeds 25 per cent. This combination preservative first will find use in treating southern pine poles where its 30 to 40 per cent added effectiveness is needed to forestall early replacement of poles (**16,17**), and yet the poles treated with this preservative will satisfy the cleanliness requirements of most consumers' specifications. No plant operational difficulties have been experienced during the entire 3 years of commercial operation in Florida.

The increased cost of the treatment can be justified on the basis of eliminating even half of the early failures of southern pine poles in line, namely, 25 per cent removal for external decay in 25 years on one recent broad scale engineering inspection study.

Results Versus Process Specifications

"Results-type" specifications stipulate what is desired by the consumer in the line of quality. There are three criteria—penetration and retention of preservatives, and cleanliness. The "process" specification tells the treater how to do the job.

In the Bell System there is a desire to get away from process specifications which direct the treater to "turn this valve, drain the condensate or make sure that the gages are being read at a specified time." Under the results-type or end-product specification the treater may use all the skill and experience he has to produce the desired results. Of course, restrictions are included so that the product is not injured in attaining the desired results. It is felt that the treater has accepted a certain, well defined responsibility in accepting an order or a contract to produce a high-quality pole and the incentive toward this goal is greater with the results-type specification.

As for *penetration* of preservative, approved sampling methods using the increment borer core have been employed successfully for some 25 yr. The disposition of the charge is based on the results found.

While the requirements may vary from utility to utility, inspection for *cleanliness* of pole surface is now mandatory with some utilities. This inspection feature was found necessary following some justifiable complaints from both the workers and the public.

Inspection for conformance to *retention* requirements based on the analysis of the treated wood is new. Such an approach to sound specification practices requires careful sampling methods to determine the retention correctly (**18,19**). It is virtually impossible to sample all the poles in a charge. It is possible, however, to analyze several groups of poles separately (for example, class 6, 30-ft and class 5, 35-ft). Poor treatment of either or both groups will be detected during routine extraction analyses for creosote content or on lime ignition tests for pentachlorophenol content. Admittedly, analyses for preservative content of the wood take somewhat longer than a calculation of the retention derived from tank gages but the delay of 1 to 2 hr before the decision as to acceptability is reached is warranted from the consumer's standpoint. It must be remembered that the physical lives of 250 or 300 poles costing some $18,000 to $30,000 to replace are at stake.

The "results-type" specification is an admission on the part of the consumer that the wood preserving industry has come of age and that it knows how to treat wood under certain specific conditions better than the consumer knows how to do so. The consumer, of course, knows best what is required of the product in terms of its practical usefulness to him.

Scarcity of Poles in the Joint-Use Sizes

We have talked about several areas in which improvement in quality of wood poles might be undertaken. There is another subject which, while not specifically falling in this category, deserves the earnest attention of all producers and consumers. There is currently a serious situation involving the availability of poles in the urban, joint-use sizes. The question is simple: "What can be done to alleviate the heavy drain being pin-pointed on the 35- and 40-ft poles in classes 4 and 5?" The answer is far from simple.

It is generally agreed that there is no over-all pole shortage. If orders are placed over the range of sizes covered by ASA 05.1-1948 there is no apparent difficulty in obtaining the poles of most class-lengths. However, it is becoming increasingly difficult for all consumers to obtain poles of the popular joint-use sizes. Perhaps the fault lies in the inelasticity of some joint-use agreements; perhaps the engineers, or those responsible for ordering line materials, do not realize that there is a tight supply situation involved. Possibly there are some instances of over-engineering. Supply catalogs generally list all the sizes of poles in the ASA dimension tables and give little, if any, information on their relative availability. One supply group reported recently:

> The increased demand for joint-use sizes precludes the possibility of maintaining stocks. This results in hand-to-mouth ordering conditions with many shipments being made from unusual distances.

In ASA Standard 05.1-1948 there are, exclusive of class 8 poles which the telephone companies do not use, 117 recognized class-lengths (sizes) covering southern pine poles. However, in actual practice the four sizes represented by classes 4 and 5, 35-ft and 40-ft comprise approximately 35 per cent of all the poles used. This is a highly disproportionate use of pole timbers and it is obvious that difficulties ensue when a producer tries to obtain poles from the normal southern pine forest made up as it often is of trees of all ages. The same holds somewhat true for Douglas fir but fortunately this and the other western species generally are found in even-aged stands.

In reviewing American Standard 05.1-1948, the Sectional Committee plans to study this problem. Perhaps some consolidation of class-lengths can be made, for example, all class 3 and 4 poles of a given length might be put together in a new class, and all class 5 and 6 poles of that length would be put in another. If this could be done the supplier might be able to furnish poles more readily because of the elasticity provided under wider dimension limits. The number of sizes on the dimensional table would be halved. It is doubtful, however, that such a radical step could be taken across-the-board because the engineering requirements must be taken into strict account.

If by chance the ultimate fiber stresses for any species are revised upward, some benefit would ensue because younger (smaller) trees could be used for a given job. Perhaps after a review of the ASTM pole break data, "dense" poles can be rated one class higher than "nondense" poles. This

is a feasible approach assuming a satisfactory definition of "density" can be formulated. Perhaps the engineers can find ways and means of providing more critical use of pole sizes for the individual job at hand; in other words, possibly class 6 or even class 7 poles could be used where formerly class 5 poles would have been used.

It is possible that an appraisal should be made of the other materials going into the outside plant with a view toward lightening or miniaturizing them. The use of polyethylene-jacketed instead of lead-jacketed cable is a practical example of what can be done to decrease the load.

This shortage of poles of joint-use sizes presents a very real problem to the pole user. The telephone industry competes with the power utilities for these joint-use poles and yet after their installation both parties own the pole, or one may rent space from the other. There appears to be no satisfactory immediate answer to the problem. Should no action be taken, the economics will be such, as time passes, that concrete, steel, aluminum, or fiber-glass poles will find their way into joint-use plant even though cost is against such an eventuality at present.

Summary and Conclusions

This paper has been prepared in a spirit of optimism. The pole producer and consumer alike are very enthusiastic about "their" product. They want to see the wood pole retain its deserving and unquestioned leadership. For decades, it has withstood the competition of metal and concrete and lately of plastic poles. As time passes there may be well considered movements to go underground in order to minimize service interruptions. Economic considerations will play a strong part in any decision. Some will want to see poles of all types eliminated for aesthetic reasons. However, the wood pole will continue its important role of supporting wires and cables overhead for many years to come. It is because of this that the several needed improvements have been singled out for discussion in this paper. The Sectional Committee 05 on Wood Poles, is preparing to do its share. Frank discussions will take place concerning many of the points raised in this paper involving untreated poles—fiber stress ratings, material requirements, and shortages of poles in joint-use sizes. The working committees of the American Wood-Preservers' Assn. are very active in the fields concerned with preservative treatment and much reliance will have to be placed on them to help solve some of our treating problems.

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DISCUSSION

MR. R. H. COLLEY.[2]—I would like to emphasize the possibilities in this combination of two very remarkable preservatives. Perhaps it is not a true synergistic effect in the chemical sense, but the two preservatives do seem to control decay organisms better than any other present preservative combination. We have an improvement in an oil type preservative that will have a wide application in the pole field. You will immediately think of the possibilities of getting rid of some of the petroleum variation in the case of penta solvents. You will also have to realize that this is a revolutionary thing in the treating industry.

We are tremendously interested because the new solution is important in connection with the use of creosote. I have been so involved in the past in this whole business of penta development and specifications for wood poles that I could not help emphasizing this particular point.

MR. E. M. CALDERWOOD.[3]—The author has placed particular emphasis on southern pine poles. This species is not readily available on the Pacific Coast and we think more effort should be directed toward the study of western species.

CHAIRMAN MARKWARDT.[4]—We like to think of the forest resource in terms of the best utilization of all the species. Our challenge is to continue to broaden the species base for wood poles as needed, and this obviously means full consideration of available western woods.

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[4] Assistant director, U. S. Forest Products Lab., Madison, Wis.

Testing of Foil-Clad Laminates for Printed Circuitry

By T. D. SCHLABACH, E. E. WRIGHT, A. P. BROYER and D. K. RIDER

Printed circuitry, an electronics automation development, employs copper-clad laminates upon which the circuits are printed and etched. The new technique poses evaluation problems outlined here with some worth-while approaches to solution

DURING the past several years the utilization of foil-clad laminates has increased tremendously, and the impetus given the use of this new engineering material has been supplied principally by the growing demands of printed circuitry. It has been conservatively estimated that some 12 million square feet of such material will be used in 1959 for this purpose. The present and projected usage thus underlines the continuing importance of foil-clad laminates and the need for suitable test methods in evaluating these materials.

Well-known testing methods are at present available for evaluating the base laminate itself, and these may be used to some advantage in testing foil-clad laminates. However, the presence of an adhesive layer and metal-foil cladding (usually 0.0014 to 0.0028 in. thick copper) on the base laminate, coupled with the fabrication methods commonly employed in printed circuitry, introduces many new problems. These problems require the development of new test methods and procedures. Active work in this area is being undertaken by many groups including ASTM, RETMA, and NEMA, and some standards are available.[1,2,3] Some of the test methods employed and developed at these Laboratories are described in this paper.

General Considerations Regarding Test Methods for Foil-Clad Laminates

The test methods required for foil-clad laminates must, of necessity, take into account the manner in which the material is to be used, and at present this use is predominantly in the field of printed circuitry.

The fabrication of an etched printed circuit board from a foil-clad laminate will in all cases involve, as a minimum, the following steps: (1) selectively coating areas of the copper or other metal foil with a suitable resistant material which will protect the underlying metal from chemical attack during etching, and (2) etching away of the uncoated copper areas with a suitable chemical reagent, thus leaving untouched the desired conductor pattern. Such processes fail to remove from between the conductors the thin adhesive layer used to clad the laminate, and further they expose these adhesive surfaces, as well as any cut laminate edges, to the etchant solution. At some later stage, components will be attached to the board by means of solder, thus exposing at least some of the board to thermal shock and soldering fluxes.

Electrical degradation of the laminate may result from the chemical etchants and soldering fluxes used in these processes so that insulation resistance, and perhaps volume and surface resistivity, tests must be performed on the processed boards. To insure a bond strength between the metal foil and the insulating base, adequate to permit processing and ultimate use of the circuit, it is necessary that peel-strength tests be performed on the clad laminate at room temperature, and also at elevated temperatures to simulate possible service conditions. Since a soldering operation is required, we are interested in the solderability of the metal foil, and the resistance of both the adhesive

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E. E. WRIGHT, member of the Technical Staff, Bell Telephone Laboratories, has, since 1927, been engaged in work in corrosion and electroplating of metals, research, testing, and development of laminated insulating materials, and most recently has concentrated on research, development, and test procedures on copper-clad laminated materials for printed circuit applications.

A. P. BROYER, technical assistant, Bell Telephone Laboratories, has for several years been concerned with testing, designing, and developing electromechanical laboratory test equipment for copper-clad laminates used in printed circuits.

D. K. RIDER, member of the Technical Staff, Bell Telephone Laboratories, in charge of development of adhesives and laminates in the Chemical Research Dept., is a member of ASTM Committees D-14 on Adhesives and C-19 on Sandwich Constructions, chairman of the 1957 Gordon Research Conference on Adhesion, and member of the Materials Advisory Board Technical Panel on Adhesives.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] NEMA Standards for Copper-Clad XXXP Laminates, Pub. LP-1-1955.

[2] MIL-P-13949 (Sig. Corps).

[3] MIL-P-26930 (USAF) Tentative.

and the base laminate to the thermal shock and short-time high temperatures encountered during soldering. We are also interested in the conductivity of the metal foil, and the temperature rise in the conductor induced by the passage of a fixed electrical current.

In addition, it is desirable to develop test methods and procedures that will be applicable, insofar as possible, not only to etched foil-clad laminates, but also to printed circuits fabricated by other means and including other types of bases such as ceramics. To aid in this adaptability it is very convenient to have all test patterns based on a fixed modular unit. The test patterns described in this paper are based on a modular unit of 2 by 2 in. This size is suitably small to be applicable to ceramic bases and also affords a degree of uniformity which is very helpful when composite test patterns are used such as the ones to be described later. All of the test methods described have been limited to sheet material.

Test Methods and Procedures

Preparation of Test Specimens

Most of the test specimens developed involve more or less complicated configurations of metal foil on the insulating base which precludes their preparation by mechanical means. Indeed, such a technique is not desirable, since in normal practice the material is not used in this manner. The test specimens are prepared as follows. The copper surfaces of a clad laminate are cleaned with a stiff bristle brush using grade FFF pumice and water, and are then thoroughly rinsed and dried. The desired resist pattern is applied using a commercial photosensitive resist in accordance with the manufacturer's recommendations. The board is etched in an air-agitated tank using 42 deg Baumé ferric chloride at 90 ± 2 F. The time of etching is limited to 15 to 30 min depending on the thickness of copper, and the copper content of the etchant is held between $\frac{1}{2}$ and 2 oz per gal as determined using a copper colorimeter or standard analytical procedures. The etched board is rinsed for 1 hr in running water, air dried overnight in a dust-free atmosphere at room temperature, and cut to final size for testing. The presently used resist material is removed by wiping with trichloroethylene on a clean cloth, and is repeated twice to assure complete removal.

A commercially available splash type etching machine has also been successfully used in the preparation of test specimens. The temperature and copper content are held to within the same limits as described for tank etching, but due to the greater efficiency in the splash etching machine the time can be reduced to 4 to 7 min depending on the thickness of copper. Although comparable results have been obtained with both types, it is strongly recommended that one or the other be used consistently for all testing programs. The ultimate criterion for any selected etching method, of course, is degree of reproducibility which can be attained, and this is absolutely essential in test-specimen preparation.

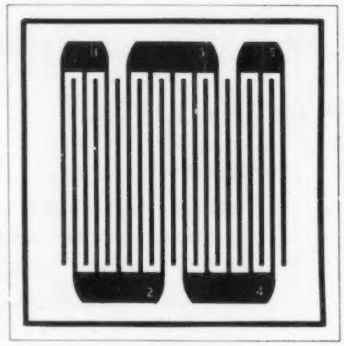

Fig. 1.—Insulation Resistance Test Specimen. Conductor Areas Are Shown in Black. Full Size.

It has been found that by carefully standardizing this preparation procedure it is possible to achieve acceptable reproducibility. This reproducibility has been judged on the basis of the uniformity of insulation resistance measurements which would be most affected by any processing variations. In essence then, such a procedure results in the testing of a processed material rather than the original raw material, but in light of the material's end use and the careful standardization, this is not objectionable. Even though such a preparation process is required to produce the test specimens, it is still possible to obtain relative, if not absolute, figures of merit for various types and grades of foil-clad laminates. Further, it is possible to obtain figures of merit for other printed circuit processes relative to the standard process described above. For this purpose, samples from a given foil-clad laminate are compared for (1) specimens prepared in the standard manner, and (2) specimens prepared using the process under consideration.

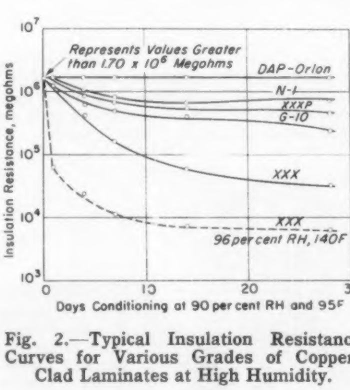

Fig. 2.—Typical Insulation Resistance Curves for Various Grades of Copper-Clad Laminates at High Humidity.

Insulation Resistance Test Method

Insulation resistance is one of the most important single parameters of a processed foil-clad laminate from the standpoint of both the design and materials engineer. It combines both the surface and volume electrical leakage between two adjacent conductors, and is extremely sensitive to traces of ionic contaminants and the electrical insulating qualities of the bonding adhesive employed.

The test specimen finally adopted for use is shown in Fig. 1. The lines are 0.025 in. wide, 0.050 in. apart, and yield a path length between adjacent terminals which is equivalent to a straight line approximately 6 in. long; the length being sufficient to obtain accurate readings on a megohm bridge but not so long as to introduce appreciable capacitance effects. Measurements at high humidity are made between terminals 1 and 2, 2 and 3, etc., in accordance with ASTM Methods D 257[4] using at least three replicates for any test on a given material. Typical curves obtained using this test specimen and the standard preparation procedure described earlier are shown in Fig. 2 for several types of foil clad laminates which were all $\frac{1}{16}$-in. thick with 0.0027 in. copper-foil cladding.

Five different types of test specimens including single lines, single and multiple interlocking combs, and the guard ring electrode of ASTM D 257 were carefully considered and tested before final adoption of the test specimen described. This test specimen has the following advantages: (1) it ranks various foil-clad laminates in a manner that is consistent with other established test methods, (2) its narrow lines and spacings closely duplicate the conductor configurations frequently employed in printed circuits, (3) it has a high ratio of insulator to metal surface thus facilitating rapid sorption of moisture into the insulating base, (4) it is of convenient size, and (5) it allows several measurements to be made on a single test specimen to aid in establishing the point to point heterogeneity of the insulating base. This last point is well

[4] Tentative Methods of Test for Electrical Resistance of Insulating Materials, 1955 Book of ASTM Standards, Part 6.

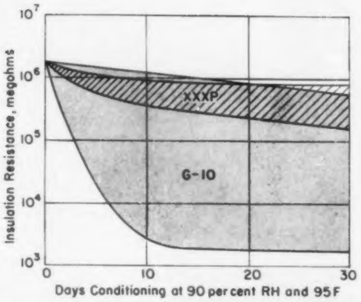

Fig. 3.—Range of Insulation Resistance Values Obtained in a Typical Single Test for Two Grades of Copper-Clad Laminate at High Humidity.

brought out in Fig. 3 showing the range of values obtained in a typical single test for two types of foil-clad laminates. The unusually large spread exhibited by this particular epoxy-glass base clad laminate (G-10 in the figure) may be due in part to short sections of poorly wetted glass fibers which rapidly sorb moisture at high humidity thus leading to high leakage paths. It may also be due in part to local surface contamination, but in either case with considerably larger spacings such as used in the guard-ring electrode shown in Fig. 7, this effect may not be noticeable because the exposed fiber sections or the area of local contamination are sufficiently small so as not to span two adjacent conductors.

This test may be carried out before and after solder dipping, as well as after any additional chemical treatments such as electrodeposition, to evaluate the effect of these treatments on the insulation resistance of the clad laminate.

Peel Test Method

The peel strength of the adhesive bonded metal foil gives a measure of how successfully the material will be able to withstand the various processing steps involved in fabrication without loosening due to thermal shock, mechanical peel, chemical attack at the edges of the conductors, or extended service at elevated temperatures with possible shock and vibration loading.

The test specimen adopted for use is that proposed by Committee 40C of the Radio-Electronics-Television Manufacturers Assn. in Standards Proposal No. 484 and is shown in Fig. 4. The peel strength values are determined on the $\frac{1}{8}$-in. wide peel strips, and the indicated lands may be used for pull-off tests. The enlarged terminal areas and the lateral connecting paths are present to permit the potential use of this test pattern for determining the current-induced temperature rise and conductivity of the foil, and as such have no bearing on the peel test.

In peel testing, the long $\frac{1}{8}$-in. peel strips are separated from the short interconnecting strips with a razor blade, and about a $\frac{1}{4}$-in. length of the peel strip is lifted manually for attachment to the jaws of the testing machine. The peel strength normal to the surface of the board (within ± 2 deg) is determined, preferably using an automatic recording universal testing machine with a loading rate of 1 to 2 in. per min. The peel load should fall within 15 to 85 per cent of the scale range of the testing machine. Since the measured peel load on a $\frac{1}{8}$-in. strip will normally fall between 0.2 and 2.0 lb, a testing machine possessing a high sensitivity, such as an Instron, is required. It is also possible to use manual loading as in the "shot bucket" method. In this case three readings per strip, on each of eight strips, are taken for purposes of averaging. Our experience indicates that these results will be 10 to 15 per cent higher than those obtained with an automatic testing machine.

The test is carried out at room temperature, 90 C, and 130 C. The 90 C is representative of a maximum storage temperature, and the 130 C is representative of a maximum service temperature for the materials tested. Typical results obtained with this type of test specimen as determined using an automatic testing machine are shown in Table I. At least two replicates for a given material are used, thus providing results from eight strips for averaging.

The use of $\frac{1}{8}$-in. wide peel strip rather than the conventional 1-in. wide strip offers two important advantages. First, a better idea of the point-to-point heterogeneity of the peel strength may be obtained, since the effect of small

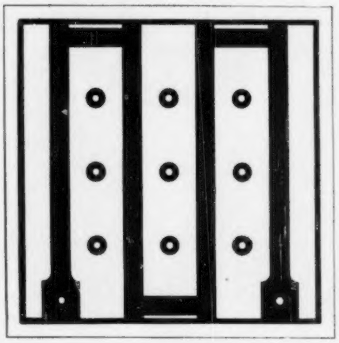

Fig. 4.—Peel Strength Test Specimen. Full Size.

unbonded areas will be greatly magnified, and second, the effect of any chemical attack at the edge of the adhesive bond will be magnified due to the narrowness of the line. This latter point is illustrated in Table II for the chemical edge attack by an alkaline gold plating bath upon a XXX laminate bonded to 0.0027-in. copper foil using a vinyl-phenolic type adhesive.

As noted previously, the test specimen provides a means of measuring the force normal to the surface which is required to separate the land from the base. For this test, a 0.052-in. hole is drilled or punched in the center of the land and a 0.040-in. tinned copper wire is soldered to the land using a lead-tin-cadmium eutectic solder and a low wattage iron. In many paper-base laminates it has been found that the adhesive bond is sufficiently strong to produce a conical-shaped, cohesive failure within the base laminate itself. Further, as high as a 45 per cent variation in this measured value may be obtained. The test has further disadvantages in that only the bond after soldering can be tested, and the results

TABLE I.—PEEL STRENGTH OF CLAD LAMINATES, LB PER IN.

Determined using proposed method based on $\frac{1}{8}$-in. wide peel strip.

Grade[a]	Range	Room Temperature		90 C		130 C	
		0.0014-in. Foil	0.0027-in. Foil	0.0014-in. Foil	0.0027-in. Foil	0.0014-in. Foil	0.0027-in. Foil
XXX[b]	Max	6.2	12.2	...	9.1	...	3.0
	Min	4.0	5.8	...	6.2	...	1.2
	Avg	5.1	9.2	...	7.5	...	2.0
XXXP	Max	9.9	12.0	6.2	9.3	4.6	6.9
	Min	6.2	11.0	4.2	7.0	2.6	5.1
	Avg	8.1	11.3	5.1	8.0	3.5	5.9
N-I	Max	8.1	10.9	5.9	10.1	3.4	4.2
	Min	6.4	7.7	5.0	7.4	1.9	3.1
	Avg	7.4	9.5	5.4	8.6	2.8	3.7
G-10[c]	Max	9.3	11.0	6.9	8.3	4.6	5.2
	Min	6.6	7.0	5.8	6.6	3.4	3.7
	Avg	7.6	9.4	6.4	7.1	3.8	4.5

[a] See ASTM Specification for Laminated Thermosetting Materials (D 709), 1955 Book of ASTM Standards, Part 6. p. 38.
[b] All laminates were $\frac{1}{16}$-in. thick.
[c] Proposed NEMA designation for epoxy-glass base laminate.

TABLE II.—EFFECT OF ALKALINE CYANIDE GOLD PLATING BATH ON PEEL STRENGTH OF XXX LAMINATE CLAD WITH 0.0027-IN. COPPER USING VINYL-PHENOLIC ADHESIVE.

Condition	Peel Strength, lb per in.			Edge attack observed, in.
	Max	Min	Average	
Initial, no plating	9.0	7.3	7.8	0
4 min in AuCN bath at 50 C	7.3	6.9	6.7	0.0010
40 min in AuCN bath at 50 C	6.6	5.7	6.1	0.0066

are somewhat dependent upon the physical properties of the solder and the wettability of the wire. At present the pull-off test is not normally employed.

Attempts have been made to use this same test specimen for determining the conductivity and current-induced temperature rise of the foil conductor as well as the solderability of the conductor, but these tests are still in the formative stage and may require considerable revision before incorporation into a standard test method.

Solder-Dip-Resistance Test Method

In order to evaluate qualitatively the solder-dip resistance of a foil-clad laminate, the test specimen shown in Fig. 5 is employed. These large, unbroken areas of the metal cladding accentuate the factors which give rise to blister formation, and are larger than the maximum solid foil area for good design practice. The specimen, comprising four 1-in. squares of copper-clad laminate, is thoroughly cleaned with pumice and water or steel wool, and fluxed with rosin-alcohol to insure complete solderability and good heat transfer through the foil to the base. The specimen is floated, foil side down, on the surface of a solder bath maintained at 450 ± 9 F. The specimen is gently agitated, laterally on the surface of the solder for a fixed time of usually 10 sec. With laminates based on synthetic organic fibers, the time is generally reduced to 5 sec due to their poorer thermal resistance. After cooling, upon removal from the solder bath, the specimen is examined visually for evidence of blistering. At least two replicates are employed for a given test.

The test result is generally expressed as blistered or not blistered, but in the former case, if desired, a rough estimate of the blistered area may be made as well as a notation regarding the interface where the blistering occurred. It is also possible to determine the time required to produce blistering for a more definitive evaluation. This may be done by exposing specimens for varying periods of time and noting the first occurrence of blistering; in some cases a distinctive popping sound can be heard when the blister is formed.

A more severe thermal shock is induced by completely immersing the test specimen in the molten solder, and an added test may be performed to determine the material's susceptiblity to blistering under these conditions. In this case, particularly with paper-base laminates, blistering may also occur within the base laminate itself due to the residual volatile content of the laminate. Examples of both types of blistering are shown in Fig. 6 for $\frac{1}{16}$-in. thick clad XXX laminate bonded with 0.0027-in. copper foil using a vinyl-phenolic adhesive.

At best this is a semiquantitative test method, but as such it is necessary and provides useful information. The test specimen and methods described are very similar to those proposed by Committee 40C of RETMA.

Water Absorption Test Method

The water absorption test specimen is simply a 2-in. square from which the metal foil has been completely etched except for a thin centerline. The 2-in. square is then cut along this centerline to yield two 1 in. by 2 in. by thickness water absorption test coupons. At least four replicates are employed for any given test. These coupons are tested in accordance with ASTM Method D 570[5] and typical results are shown in Table III. They have been found not to differ significantly from those obtained using the 1 in. by 3 in. by thickness specimen required in ASTM Method D 570. It may be stated that the results of this test are not very significant for the better electrical grades of foil-clad laminates since they all exhibit only moderate moisture absorption which probably does not bear a direct relationship to the observed insulation resistance of these materials at high humidity. For the poorer electrical grades of foil-clad laminates it is perhaps of more value.

TABLE III.—WATER ABSORPTION OF LAMINATES, PER CENT.
(Determined using proposed method.)

Thickness, in.	Grade XXX	Grade XXXP	Grade N-1	Grade G-10
$\frac{1}{32}$	2.34	1.18	0.63	0.69
$\frac{1}{16}$	1.25	0.60	0.47	0.33
$\frac{3}{32}$	0.76	0.44	0.31	0.21
$\frac{1}{8}$	0.60	0.32	0.24	0.16

[5] Tentative Method of Test for Water Absorption of Plastics, 1955 Book of ASTM Standards, Part 6.

Fig. 5.—Solder Dip Resistance Test Specimen. Full Size.

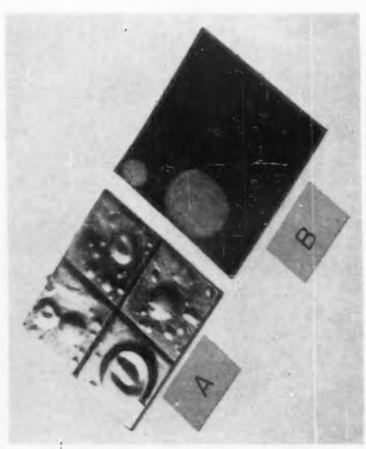

Fig. 6.—Solder Dip Resistance of Clad XXX Laminate. A. Foil blistered after 10 sec immersion in solder at 450 F. B. Laminate blistered after 10 sec immersion in solder at 450 F.

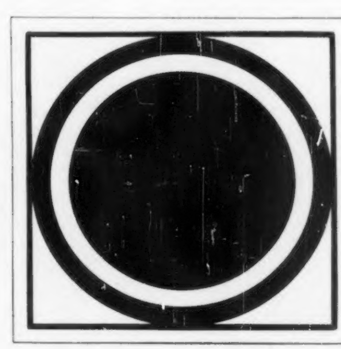

Fig. 7.—Volume and Surface Resistivity Test Specimen. Full Size.

Volume Resistivity and Surface Resistance Test Method

The specimen employed is shown in Fig. 7. The outermost diameter of the guard electrode is 2 in., and the width of the guard electrode as well as the spacing between electrodes is $\frac{1}{8}$ in. The test specimen and the associated test method are identical to that described in ASTM Method D 257[4], except in the method of test specimen preparation.

The specimens are prepared by first completely etching the copper from the 2-in. square in the standard manner including the rinsing and drying steps. Following this, a suitable conductive silver paint of the proper viscosity is used to silk-screen the electrode pattern on the base laminate. After air drying, terminals are affixed using a conductive silver-loaded epoxy adhesive, and the completed specimen is given a final cure in an oven at 250 F for 2 hr. From this point on, the specimen is tested in accordance with ASTM Methods D 257. At least two replicates are employed for any given test.

Earlier in this work an effort was made to use the adhesive bonded copper foil as the electrode material, but the fact that the metal foil is nonporous and permanently bonded to the base laminate results in much slower rates of moisture sorption into the laminate at high humidity. The volume resistivity values in such a case may be as much as 50 per cent higher than would be obtained using silver-paint electrodes. Perforated foil electrodes have also been used. These increase the rate of moisture sorption somewhat, but are still not equivalent to silver-paint electrodes. The surface resistance values, of course, are not affected nearly as much when metal-foil electrodes are substituted for silver-paint electrodes, but since both volume resistivity and surface resistance values are determined on the same specimen there is no advantage in using a separate specimen for each determination. At the present time silver-paint electrodes are used for all tests involving the measurement of volume resistivity or surface resistance.

One word of caution should be mentioned at this point in connection with silver-bearing electrodes. On certain types of laminates, and when using certain silver-containing paints or pastes, there is the possibility of silver migration when the specimen is subjected to a direct voltage at high humidity. Silver migration so produced can result in complete electrical shorting of the specimen. Generally, in tests of this kind the direct voltage is not applied for a sufficient period of time to produce any detectable migration, but the possibility exists and should be checked under the conditions of the test.

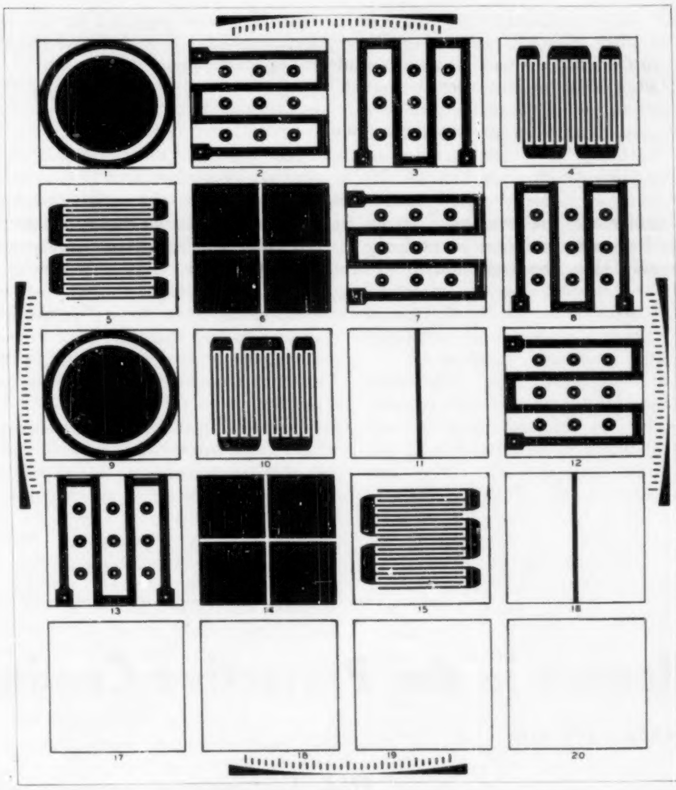

Fig. 8.—Master Test Pattern for a Single Sided Clad Laminate.

Other Test Methods

For all of the other electrical and physical parameters which may be desired, the appropriate ASTM test method is employed where applicable.

In addition, at the present time we are considering the incorporation of capacitance and inductance test methods although they are still in the early stages of development. A test method and specimen for evaluating printed circuit boards containing plated feed-through connections has also been developed, and used to a limited extent. These tests are important for the utilization of foil-clad laminates in many printed wiring applications, but as yet they have not been perfected.

Master Test Pattern for Foil-Clad Laminates

As a final step in establishing the test methods for foil-clad laminates, a master test pattern was developed which in essence is a composite of the test specimens previously described. The master test pattern for single sided clad laminate is shown in Fig. 8. Such a master test pattern provides two important advantages: (1) it allows all the requisite test specimens for the evaluation of a given material to be prepared simultaneously, thus minimizing the effect of any possible variations in the specimen preparation procedure, and (2) to a limited extent, it represents a standardized sampling technique for a given foil-clad laminate.

In the figure shown, the individual test specimens on the master test pattern have been spatially arranged so as to allow test sampling from both the edge and center areas of the processed board, and in directions mutually perpendicular to the grain of the laminate. For laminates clad on both sides the master test pattern is similar in size and test specimen disposition with the exception that half of the specimens are faced on the reverse side so that both foil-clad surfaces may be evaluated. Each test specimen position on each side is given an identification number for ready reference. In testing a sample sheet (36 by 42 in.) of a foil-clad laminate, one master test pattern is generally prepared from the center of the sheet and another from a corner of the sheet.

The method of preparation of the test specimens provides a $\frac{1}{2}$-in. trim edge

around the entire master test pattern so that after chemical processing this trim edge may be removed to minimize the effect of etchant penetration through the exposed raw edges of the processed board. In this trim area, "quality-of-etch" patterns have been included on all four sides which allow an estimate to be made of the severity, duration, and uniformity of etching. With increased severity or time of etching the extremely thin central portion of this pattern will be etched away completely, and the distance separating the tips of the resulting wedges can be employed as a "quality-of-etch" parameter.

After completing the preparation procedure for the master test pattern, the individual test specimens are cut out, and tested in accordance with the appropriate test method. It is also to be noted in Fig. 8 that additional space has been provided for the future inclusion of other test specimens as the need may arise.

Summary

An approach to the testing of foil-clad laminates has been presented. Its departures from the more conventional test methods have been dictated by both the material under consideration and its principal end use in printed circuitry. The intent in every case, however, was to make the test methods and accompanying test specimens as widely applicable as possible, and also to utilize existing test methods wherever practicable.

The testing procedures outlined here have been employed by diverse groups in this laboratory for over a period of $1\frac{1}{2}$ yr, and the principal shortcomings and advantages of each have been pointed out based on our experience with these methods. The numbers of individual test specimens upon which these generalizations are based, for the various methods described, range from the hundreds into the thousands. It is apparent that only a few of the basic parameters of interest to both the materials and design engineer have been covered so that one may expect not only improvements in the methods described but also the inclusion of new test methods in the future. It is important, however, that the standardization of test methods for foil-clad laminates be accomplished as soon as practicable in light of present and anticipated expansion in this field and the present lack of suitable methods. It is hoped that this work may contribute to the realization of this objective.

Silicones in the Protective Coatings Industry*

By HAROLD L. CAHN

High heat-resistant enamels, additives for correcting film defects, electrical insulating coatings, and masonry water repellents are among the many silicone products

THE original aura of magic that first surrounded the word "silicones" has given way to an appreciation of the manifest usefulness of these materials. While silicone products have been commercially available for about ten years and have exhibited consistent growth during that period, many people are still awed to learn that they are put to so many uses in so many widely divergent industries. Without going beyond the confines of the protective coatings industry, we can point to a substantial number of applications.

The pioneer application of silicones in the protective coating field was in the use of a silicone resin as the sole vehicle for high-temperature-resistant paints. Since that limited beginning, silicone use in this field has mushroomed and now includes: organic vehicle modifiers, silicone copolymer vehicles, electrical insulating coatings, additives for correction of film defects, additives for better processing, and structural masonry water repellents

Pure Silicone and High-Silicone Vehicles

The classic example of the use of silicone resins is in high-temperature aluminum paint, wherein the vehicle is 100 per cent silicone resin. To be suitable for this purpose, the resin must meet certain requirements. The control testing of the resin for specified physical constants is much the same as it would be for alkyd resins. Perhaps the greatest difference would be in the reason for an acid-number specification. In alkyds it is a measure of the degree of esterification. In silicone resins, the acid number determination is a measure of the freedom of the resin from by-product hydrochloric acid, which is formed during the hydrolysis of the chlorosilane intermediates, from which silicone resins are made.

The finished paint must meet most of the same requirements that apply to conventional paints, but the primary requisite is that it withstand high heat. A paint such as this, based on a 100 per cent silicone resin vehicle, would find its greatest utility in service at temperatures up to about 500 F. Of course, it could be used at temperatures to 1000 F, or even higher, but for this type of service, paradoxical as it may seem, a

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NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the atteniton of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

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less costly paint can be formulated and used effectively.

This apparent paradox is readily explained. The solids of a silicone resin are nonvolatile at all ordinary temperatures, and only slightly volatile during long exposure at 500 F. Thus, for this type service, a heat-stable resin is necessary.

On the other hand, for service at 1000 F or higher, the circumstances are quite different. At this temperature, even the silicone will volatilize, leaving the aluminum fused to the steel surface. During the initial heating, the organic portion volatilizes and the silicone resin sets the aluminum film in place. As the temperature rises further, the silicone resin volatilizes while the aluminum film is becoming fused to the steel. Therefore, only enough silicone vehicle, approximately 50 per cent, to accomplish this end is used.

The only way such paints can be tested is to expose them to actual service temperature conditions. To be satisfactory, they should show no general film deterioration and no more than slight difference in appearance from unexposed films.

Most consumers of this type paint, however, in both private industry and Government, have established their own specifications in accordance with the intended service. Some will require a certain degree of flexibility and abrasion resistance after a specified heat exposure. Others may require corrosion resistance, as indicated by a salt spray exposure, after high-temperature heat aging. Certain possible variations in the formulation can usually adapt these paints for use under special conditions.

Typical applications for such high-temperature aluminum paints are boiler stacks, exhaust stacks, mufflers, furnace and oven exteriors, high-temperature processing equipment, exhaust manifolds, and jet-engine components.

Aside from these metal pigmented coatings, there are several applications where white and colored silicone paints and enamels are needed for adequate protection under specified service conditions.

Home incinerators and reflectors for certain types of lights that generate high heat are coated with straight silicone or high silicone-content enamels. Various colored and iridescent metallic finishes are used to provide decorative as well as protective coatings for space heaters, ovens, and other appliances and structures subjected to elevated temperatures in normal service.

In addition to the usual control tests such as would be performed on conventional organic coatings, the principal test requirement of these finishes is heat resistance. After specified exposures at or above anticipated service temperatures, film integrity must remain intact. The color must be essentially unchanged. The degree of permissible color change will vary depending on circumstances. Gloss finishes must remain glossy, although in many cases some drop in the actual gloss reading will be permitted without jeopardy to the film or the service for which it was intended.

High silicone content copolymers were developed for service slightly less rigorous than that for which pure silicone resins are used. Certain areas of ranges or other industrial items may be subjected to moderately high temperatures such as 350 to 450 F. Lamp shields on ranges may not even get to 350 F but are exposed to fumes and steam from cooking and to general warm air aging. Conventional baking enamels yellow while the porcelain working areas remain pure white. Finishes based on high-silicone copolymers, with the proper organic intermediate, will withstand all of this and remain white.

At least one of these copolymers has gone far beyond expectations in color retention. A white finish based on it has withstood in excess of a full week at 480 F without loss of color. It is rivaling the pure silicone here, although it does lose some of its gloss under these extreme conditions.

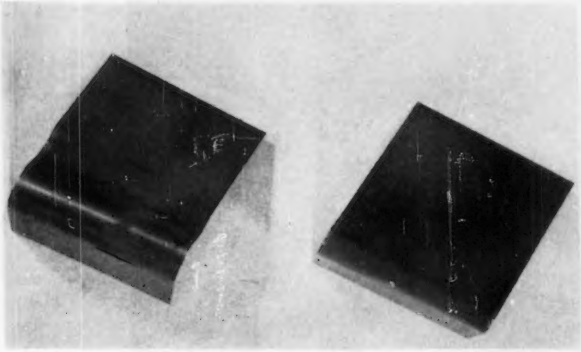
In multicolor metal decorating, the baking temperature may not be excessive but a white background may be required to remain white through three or four or more successive bakes. Conventional baking enamels are hard pressed to meet this, but a silicone copolymer does it with ease.

Resins of this type have been formulated into white appliance finishes and found to possess many other desirable properties in addition to a high degree of heat resistance. Hardness, mar resistance, flexibility, soap resistance, vegetable fat and fruit juice resistance have placed such finishes high in appliance finish ratings.

In addition they have been found impervious to JP-4 jet fuel and petroleum-base aircraft hydraulic fluid in immersion tests.

Low-Silicone Organic Blends and Copolymers

For basically the same purposes, where a lesser degree of heat resistance is required, low silicone content blends and copolymers are performing a valuable service. Coatings containing up to 25 per cent of total solids as silicone solids have markedly improved weather



All Alkyd Vehicle 25/75 Silicone Alkyd Vehicle

Fig. 1.—The ability of a silicone to upgrade alkyd finishes is demonstrated by these olive drab paint panels exposed to 480 F for 24 hr. The all alkyd coating has lost its integrity while the 25–75 silicone-alkyd coating is in excellent condition.

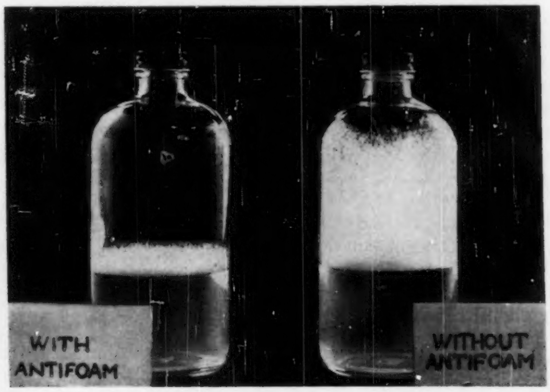


Fig. 2.—A tiny portion of a silicone antifoam accounts for the marked difference in the foaming of the otherwise identical soap solutions in these test bottles. The test illustrates how use of the silicone antifoam will make possible fuller use of productive capacity.

resistance and substantially upgraded heat resistance over 100 per cent alkyd-base finishes. An interesting test, under exaggerated conditions, illustrated this quite dramatically. Two olive drab paints were prepared identically except that in one 25 per cent of the alkyd vehicle solids was replaced by an equivalent quantity of silicone resin solids. After the initial bake there was practically no difference, but after an additional 24 hr at 480 F the all-alkyd paint had essentially lost all its film integrity while the silicone-modified one was in good condition, as shown in Fig. 1.

While such coatings will air-dry satisfactorily, those with higher ratios of silicone resin will require baking. The degree of heat resistance will vary with the silicone content. Other properties will depend, to a large extent, on the organic vehicle and the pigmentation.

Inasmuch as it is not our purpose to discuss formulation principles here, no details of pigmentation will be given. However, we should note that success with silicone protective coatings depends on the careful selection of pigments for their inherent resistance to change at high temperatures and their reactivity with silicone resins.

Electrical Applications

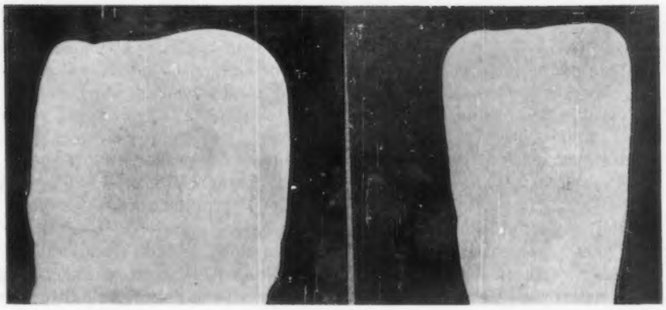
Closely allied to the conventional protective coatings field of application, and actually a specialized phase of it, are electrical insulating coatings. The primary purpose of these coatings is not to insulate but to protect the insulation that is already an integral part of the equipment. Such coatings keep out dirt and moisture which could eventually cause short circuits and current leakage.

While the coating constitutes the protection for the insulation, it is obvious that it too must have at least a minimum of insulating value. Thus, one of the principal prerequisites for an electrical insulating coating is that it pass a dielectric strength test. Silicone resins are noted for their high dielectric strength and resistance to carbonization on exposure to arcing, such as might occur between exposed transformer terminals. Before being acceptable for electrical service, they must be further tested for resistance to corona degradation. This is an electrical phenomenon wherein charged particles present in voids in electrical insulation bring about the formation of ozone and nitrogen oxides which rapidly degrade most insulation materials.

Specific tests are conducted for determination of the acceptability of insulating materials on the basis of arc and corona resistance. The silicone-base coatings are exceptionally resistant to damage from these sources.

Heat resistance is, of course, a primary factor. The higher the power output of a piece of equipment, the hotter its operating temperature. With insulation unable to tolerate high temperatures, the heat must be dissipated over larger areas. In many cases, the proved heat resistance of silicone insulation has permitted the equipment manufacturer to double the power output of any given motor frame size.

Because of the thermal stability and extended high-voltage endurance of silicone materials, heavy-duty power cable with insulation fabricated from silicone rubber-coated glass cloth has doubled the power-carrying capacity of its predecessors.



Pigment Flotation — Flotation Corrected Full Color Development.

Fig. 3.—These panels illustrate the comparison between the performance of a paint before and after the addition of a silicone fluid used to correct floatation of tinting pigments.

Silicone Additives

The field of silicone additives in the protective coatings industry is an example of good things coming in small packages. Used in ratios of a relatively few parts per million, silicones are amazingly effective in performing specialized corrective functions.

Varnish and resin cooking are the outstanding applications for the use of silicone antifoamers. Heat-reactive phenolic resins, for instance, foam badly due to condensation. Often one third to one half the kettle capacity is allowed for foam in order to prevent overflow and potential fire. Usually 25

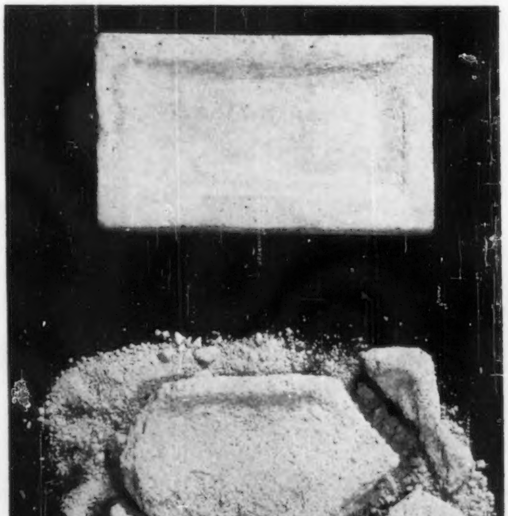


Fig. 4.—Prior to exposure to 35 freeze-thaw cycles, these bricks were identical except for the silicone masonry water repellent treatment given the sample at the top of the figure.

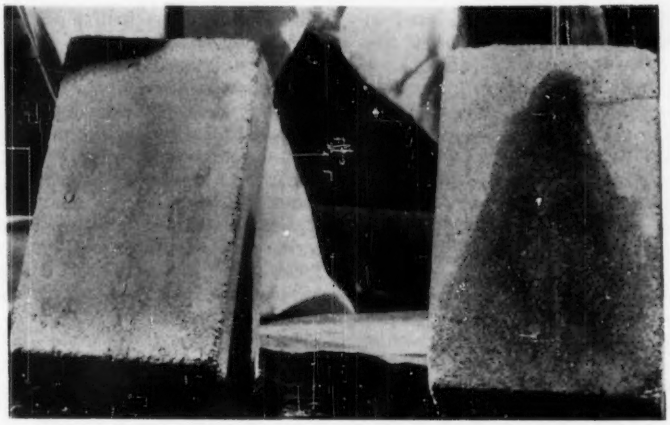


Fig. 5.—Laboratory specimens illustrate the marked difference in water absorption between the silicone treated brick (left) and the untreated specimen (right). Note beads of water on the treated brick.

to 100 ppm of silicone foam suppressant markedly reduces or entirely eliminates this hazard, (Fig. 2) thus enabling the processor to make fuller use of his kettle capacity.

In latex and latex paint manufacture serious foam problems are controlled by silicone products used in approximately the same proportions.

Flotation of tinting pigments is a phenomenon that has at one time or another plagued all paint manufacturers. Today it would be difficult to find a plant that does not use a silicone fluid for correction of this problem. Simultaneously they serve other purposes such as pigment wetting agent, antisilking agent, and others.

The effectiveness of a silicone additive in preventing pigment flotation is readily observed by comparing a coating containing it with a control containing none (Fig. 3).

Water Repellents

Probably the fastest growing application of silicone materials in the protective coatings industry today is the use of silicone water repellents on masonry.

A water-soluble silicone, sodium methyl siliconate, is the only material that was found, in independent tests, to perform satisfactorily in making limestone water-repellent. This material is manufactured as an aqueous alkaline solution, infinitely dilutable with water. It is applied at 2 to 4 per cent silicone solids concentration, but once dried, it is no longer water soluble. This silicone material cures upon exposure to carbon dioxide in the air, forming an effective water repellent.

This material is gaining increasing use in its application to roadways, piers, and abutments of concrete highway bridges because of the freeze-thaw stability that it imparts to concrete. Wetted specimens on a moving belt are alternately frozen and thawed in continuous 4-hr cycles until differences are detected. Figure 4 shows the difference between a treated and an untreated concrete brick after 35 such freeze-thaw cycles.

The light reflectance of wet concrete is also favorably affected by treatment with this water-soluble silicone. Only a slight reduction, of the order of 10 per cent, is observed, whereas untreated wet concrete has only half the light reflectance it had when dry. This increased visibility of wet concrete pavement has excited the interest of highway engineers who are giving serious thought to this application.

Probably the best known and most widely used silicone masonry water repellents are those specially formulated from solvent-soluble silicone resins. Applied from dilute solution, they do not change the color or appearance of the masonry but do, in effect, provide an invisible barrier against external water absorption into the pores of the masonry. They do not seal the pores, but line them, thus allowing internal moisture to escape while repelling water from the outside.

It would be difficult to place in order of importance the advantages that silicone masonry water repellents, as protective coatings, have brought to the consumers of such products. Probably the one most often thought of is the retarding or eliminating of the passage of moisture through the masonry to the extent that interior paint flakes and peels (Fig. 5).

It has been said that well constructed and well maintained masonry is practically ageless. Prevention of physical damage to masonry as a result of water freezing in the pores must be regarded as one of the primary functions of silicone masonry water repellents. The benefit to be gained is similar to that illustrated previously for the water-soluble silicone.

Minimizing or completely eliminating efflorescence on masonry walls, as a result of absorption of external water, is another advantage to be gained from

Fig. 6.—Silicone masonry water repellents are frequently applied to halt or minimize efflorescence such as that seen on half of this brick, shown resting in a 10 per cent salt solution. However the siliconed portion of this half treated brick displays a clean surface, unmarred by the unsightly appearance of salts leached to the surface.

the application of a protective silicone water-repellent coating. In Fig. 6 a half treated brick is shown immersed in a 10 per cent salt solution. The efflorescence on the untreated half, as contrasted with the clean, dry, treated half illustrates the effect of this treatment.

Since these water repellents have come to be recognized as a true indication of progress in the protective coatings industry, their use has become more and more widespread. In fact, the clear solvent-base silicone water repellent solution has become the subject of several specifications. The one of which most use is made is the Federal Interim Specification SS-W-00110 (GSA-FSS). This is currently in the process of being reviewed for advancement to the status of a fully coordinated Federal Specification. Similar action is being taken in Canada by the Canadian Specification Board.

The principal test procedures outlined therein for quality control are, in addition to determination of silicone resin solids, tests for "breathing" of treated masonry, prevention of efflorescence, and for resistance of treated masonry to water absorption.

In the "breathing" test a weighed brick is coated on the four edges and one bedding surface. After curing, the coated brick is totally immersed in water until it is completely saturated (through the uncoated surface). It is wiped superficially dry, weighed, and sealed with wax (uncoated side down) to waxed paper. The specification requires that, in one week, at least 50 per cent of the absorbed water shall have evaporated through the pores of the five treated surfaces.

A test for efflorescence is made in a manner very similar to that illustrated in Fig. 5 except that the same brick used in the "breathing" test is placed uncoated side downward in the salt solution and left for 7 days. No efflorescence should appear on the surface.

The real quality of the product as a water repellent is determined in the water absorption test. Cured mortar cubes, of such specified composition as to have a standardized water absorption of 8 per cent minimum, are used in this test. After complete coating by dipping, the water repellent is allowed to cure for 48 hr in air at room temperature. The cubes are then partially immersed in water for 72 hr. In order to pass this test, the water absorption of the treated cubes must be less than 1 per cent of the dry weight of the cube.

One additional application of the silicone water repellents is their incorporation, in relatively small quantities, into other conventional finishes. Such use as additives has resulted in their imparting water-repellent properties to these finishes. For example, water absorption tests on masonry coated with a conventional masonry paint and with the same paint modified with a silicone water repellent showed that the latter permitted only a small fraction of the water absorption exhibited by the unmodified coating.

Conclusion

This multitude of applications of silicone products in the protective coatings area alone, not to mention other industries, is indicative of a rapidly advancing silicone technology. The accelerated pace of our engineering technology is constantly creating the need for coatings having properties which the silicone materials alone impart. The inevitable consequence is a growing list of specifications for finishes incorporating significant quantities of silicone products.

DISCUSSION

MR. JOHN J. WHITE.[1]—I think you identified the federal specification for water repellents as SS-W-00110. In the latitude of the Middle-Atlantic states and assuming a coating thickness of say, 1 mil, what average life might be expected of such coating?

MR. H. L. CAHN (*author*).—I would discount the 1-mil thickness because it is pretty difficult to measure the thickness of a coating of this sort since it follows the pattern of the masonry and we do not usually get a film thickness measure. The life is usually spoken of in terms of 5 yr; and this is based, of course, on the masonry being in good mechanical repair. The coating is not a sealer. It does not cover cracks or holes or breaks between mortar and the masonry brick or block and it will not stop water from going in through these openings. It merely prevents water from being absorbed by the inherent porosity of the masonry.

MR. WHITE.—What is the federal specification number for the silicone-coated glass cloth insulation?

MR. CAHN.—The number is MIL-I-17205B.

MR. R. R. LITEHISER.[2]—Were the protective coatings shown in Figs. 4 and 5 the same? One shows resistance to freezing and thawing, and the other illustrates the water repellency. Is that the same coating or the same protective treatment?

MR. CAHN.—Actually, I do not know. But, they could be. They would have done about the same thing. The one in Fig. 4 which shows the brick completely broken apart is the sodium methyl siliconate, and this is a little bit more effective on concrete than the solvent-base material.

MR. LITEHISER.—Could both of these types of silicone protective treatment be obtained under specification SS-W-00110?

MR. CAHN.—No. That specification is strictly for the solvent solution.

MR. LITEHISER.—Where do we get the specifications on which we may base the protective coating which was so effective in increasing resistance to weather or resistance to freezing and thawing?

MR. CAHN.—I do not know if any specifications exist. Some states either have written this in or are in the process of including something like this in their specifications for highway bridges. I believe Ohio is one of them.

MR. LITEHISER.—Yes, we are one such state, and I was quite interested to find out just how we could specify this more protective treatment, the one that gave a marked improvement in durability.

MR. CAHN.—That is the water-soluble material.

MR. LITEHISER.—Does the work done show that a protective coating such as that used in Fig. 4, the one that increased resistance to freezing and thawing, would be resistant to the splashing of chemicals such as salt and other ice-removal agents against our bridge walls and railings?

Our concrete in Ohio is markedly susceptible to the effect of the chemical solution that results from our snow and ice-removal practice. As a car goes over a bridge, it splashes the solution up against the concrete sidewall. The solution runs off and is splashed up again by the next car, and so on, so that we have a very grueling practice which increases the rapidity with which we have freezing and thawing cycles.

[1] Parsons, Brinckerhoff, Hall & Macdonald, Consulting Engrs., New York, N. Y.
[2] Department of Highways, Columbus, Ohio.

MR. CAHN.—This silicone material does prevent the wetting of concrete and since the salt is in the form of a waterborne solution, the effect of salt is greatly minimized. It has to get into the concrete in order to do the damage, and if it is kept out on the surface it is not very harmful if the surface is treated.

MR. JULIAN GILES.[3]—Does the use of the silicone water repellents on masonry building have any effect on subsequent painting of the building; and, if so, does the use of the paint over the water repellent cause any lack of effectiveness of the water repellents?

MR. CAHN.—Those who have used the silicone treatments and painted over them have found no difficulty in adhesion of paint over the silicone water repellents. Paint over a silicone treated wall only adds a little more to the protection. This applies to solvent-based or latex paints. Cement-base paints, wherein water is a reactive chemical rather than just a carrier, are not suggested for use over silicone-treated surfaces since such surfaces must be well wetted by water for best adhesion of the cement paint.

MR. S. C. HARRIS.[4]—You mentioned a new specification that calls for a silica content of the vehicle solids. This will not provide for the distinction between copolymer and blended vehicles. What do you think about the comparison?

MR. CAHN.—The vehicle solids contain a minimum of 18 per cent silica and in calculating backwards from that point, depending on the silica content that you would get from igniting a silicone resin, you need somewhere in the neighborhood of 35 per cent silicone resin solids in the total nonvolatile vehicle matter. So, if you want to exceed the minimum that is called for, you are perfectly at liberty to do so, but you do not have to. On the other hand, you may not want to go to 100 per cent, or even a high silicone percentage because of the other specification requirements such as short drying time, and a relatively short low-temperature bake.

MR. HARRIS.—I meant one can get the silicone content either by blending a silicone or using a copolymer.

MR. CAHN.—One can do it either way. The only thing is that if you blend cold, you have a lot more versatility in the alkyd. And this may prove to be the only way. I am not certain yet if it is the only way you can do it because you do have a rather stringent viscosity requirement on the finished paint. If you use a silicone copolymer, that is it; but, if you use a silicone resin blended with an organic resin, you have a lot of freedom as to the viscosity of the organic modifier that you use in order to get the finished paint within the specified viscosity limits.

MR. S. S. BRAZELTON.[5]—Does the paint which is formulated with 25 per cent silicone in the vehicle remain corrosion resistant for a relatively long time, say, for 2 or 3 months before application of heat to the surface?

MR. CAHN.—If I understand you correctly, you are asking about this 25 silicone, 75 alkyd resin-based paint. Yes, if you use, of course, the inhibitive pigments in a primer or whatever the coating may be. If you use pigments that will tend to give you corrosion resistance and a good drying vehicle, the paint will air-dry and serve very satisfactorily. If you use another type of vehicle, for instance, one that is best when it is baked, you will have to bake it in order to get the best results. Up to the 25 per cent silicone level the properties are very much those of the alkyd that you may blend with it. If you have a flash-drying alkyd you will have a flash-drying modified coating. If it is a 24-hr drying material, it will dry satisfactorily and stand up in the weather or other conditions that the alkyd itself will take. The only difference is the vastly upgraded heat resistance as indicated in Fig. 1.

MR. J. HOWARD RIGDON.[6]—In using this type of clear coating on masonry structures, you say it has a life of about 5 yr. This varies in different locations. Since it is a clear coating, how do you determine when to recoat?

MR. CAHN.—If you are going to wait until you have visible evidence of a need of recoating you have gone a little too far. Therefore, this does vary. It varies in different climates and under different conditions. On the East Coast and, more often than we like to have it, in the Northeast, when we get hurricanes, we may need to recoat more often. Because foreign matter in the air which may be abrasive may have a bearing on the life, this 5 yr is a pretty flexible figure. A good way to determine what you have is to observe it after a period of service, during a rain and see what degree of watershedding you have. Of course, you will not note a sharp line—that is—one day it is good and the next day it is not good. It is a matter of judgment by observation after a period of time, whether you think it needs recoating or not.

MR. EUGENE B. MOORE.[7]—Is there any application of silicone in or on vinyl coatings, either spray or laminated types?

MR. CAHN.—I know of no application to vinyl coatings. As far as *in* vinyl coatings is concerned, the most that we know is that there is little, if any, compatibility. This may not be the last word but it is the way it looks at the present time. The water-soluble type, sodium methyl siliconate has been used in polyvinyl acetate latex paints with some improvement in waterspotting resistance and earlier scrubresistance.

MR. E. D. BOTTS.[8]—We have variations in temperature of 150 F in some parts of California in the course of a year and in winter we do have spalling trouble. Is the water-soluble silicone better on the masonry than the solventbase silicone resin?

MR. CAHN.—Yes. In comparative tests this water-soluble type has proved to be more satisfactory—appreciably more effective on typical highway types of applications than the solvent-soluble type.

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[3] Douglas Aircraft, El Segundo, Calif.
[4] Bradley Paint Co., Los Angeles, Calif.
[5] Los Angeles Dept. of Water and Power, Los Angeles, Calif.
[6] City Sewer Design, Bureau of Engineering, Los Angeles, Calif.
[7] International Business Machines Corp., San Jose, Calif.
[8] California State Dept. of Public Works, Division of Highways, Sacramento, Calif.

Combination Creep-Rupture Test Specimen

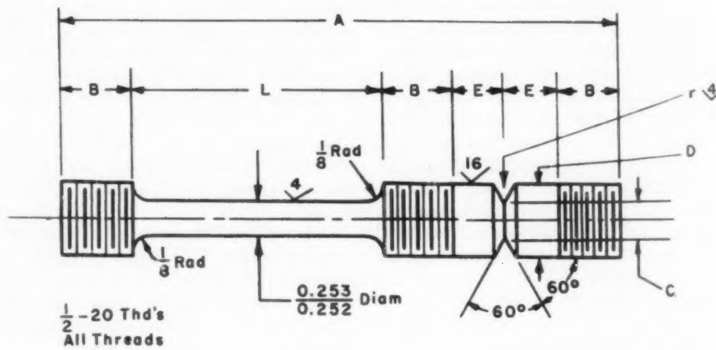
By M. J. MANJOINE

A specimen which combines a smooth and a notched test section has proved worth-while in creep-rupture acceptance testing and in the development of new alloys and heat treatments

In the development of new alloys or heat treatment of alloys and in the acceptance testing of commercial heats of alloys for high-temperature service, it is usually necessary to determine their creep-rupture strength and their notch sensitivity. This is done by performing creep-rupture tests on smooth and notched bars of the material. Since the duration of these tests may be long, it is desirable that time be saved by minimizing the number of tests. Since notch sensitivity may vary for different positions in the lot of material (because of differences in history and composition), it is necessary that the notched test section be taken from a position as close as possible to that of the smooth bar test section and that the heat treatment be the same for both notched and smooth bars.

The following describes a test specimen which has proved worth-while in acceptance testing and in the development of new alloys and heat treatments. The proposed test specimen shown in Fig. 1 consists of a combination smooth test section and a notched test section. Since they are tested simultaneously, the testing time is reduced; as they are located in the same specimen, their position in the lot of material and their heat treatment must be the same. When either test section is broken, the other can be reloaded and continued. This may not be necessary if the test record obtained up to that time is sufficient to determine the properties desired.

An example of the use of this specimen in the development of alloys and in acceptance testing is described below.



Item	A	B	C	D	E	L	r	K_t
1	4	1/2	0.253/0.252	0.501/0.499	3/8	1.76/1.75	0.0052/0.0048	4.8

Fig. 1.—Combination Test Specimen.

Figure 2 shows the results of tests on notched and smooth bars of 15 heats of Discaloy with varying hardener content (per cent titanium). The data[1,2] for a stress of 60,000 psi and 1200 F are plotted and the curves represent the probable average properties for heats of Discaloy. These curves have been reproduced in Fig. 3 to demonstrate the region in which various criteria of strength are used in the evaluation of materials.

Let us first consider the use of this specimen in routine testing in which both the notched and unnotched rupture lives are desired. Figure 3 shows that specimens from all heats with a hardness below that at *B* will first fail in the smooth bar section and that those above *B* will fail in the notched section. In both cases the remaining unbroken portion of the test specimens would be reloaded and continued to failure. The testing time is reduced by a value approaching $\frac{1}{2}$ for heats near *B*. More important is the fact that the reliability of the data has been increased because both test sections have the same history.

To date, the most important application of this specimen has been in accept-

MICHAEL J. MANJOINE, research engineer, Mechanics Dept., Westinghouse Research Labs., Pittsburgh, Pa., since 1940, has published many papers on the effect of strain rate on the plastic flow of metals and on creep-rupture testing, one of which with E. A. Davis, won the ASTM Dudley Medal in 1953.

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[1] F. Hull, E. Hann, and H. Scott, "Effect of Notch and of Hardness on the Rupture Strength of Discaloy," Symposium on Effect of Notches and Metallurgical Changes on Strength and Ductility of Metals at Elevated Temperatures, p. 49, Am. Soc. Testing Mats., Symposium issued as separate publication *STP No., 128* (1952).

[2] From original data not previously published.

ance testing of heats or lots of material to be used for elevated temperature service. The criteria for acceptance may be as follows: for a stress of 60,000 psi at 1200 F (1) the rupture ductility for the smooth bar must be 5 per cent or greater; (2) the rupture life of the notched bar for a given stress concentration factor must be 25 hr or more; (3) the rupture life of the smooth bar must be at least 10 hr. At the bottom of Fig. 3 the limits are shown for these criteria. For criterion (1) above, all heats to the left of *B* (for region shown) have at least 5 per cent strain at rupture. For (2) all heats to the left of *C* have a notched rupture life of 25 hr or greater. For (3) all heats to the right of *A* have a rupture life of 10 hr or greater. The region in which the heats pass all criteria is, therefore, from *A* to *B* and these are the only heats that are accepted for the particular service.

Finally, let us consider the use of this specimen in the development of high-temperature alloys or heat treatments for these alloys. In this case we are usually interested in an assurance that the material is notch-insensitive at the service temperature. The criteria, for example, may be as follows: For a stress of 60,000 psi at 1200 F (1) the rupture life of the smooth bar must be 10 hr or greater; (2) the rupture life of the notched bar at the same stress and temperature must be greater than that of smooth bar. A material, therefore, is acceptable only if its combination test specimen fails after 10 hr in the smooth test section. In this case only a single test is required, that is, no reloading is necessary. Again the reliability of this test specimen is superior to that of two separate specimens, one smooth and the other notched.

It should be pointed out that this specimen can be varied to obtain different stresses in the notched and smooth test sections and different stress concentration factors for the notched section, by changing the diameter of the test sections and the radius of curvature at the root of the notch. Thus the criteria for acceptance can include different stresses or different rupture lives for the notched and smooth sections and a stress concentration factor dictated by the service application.

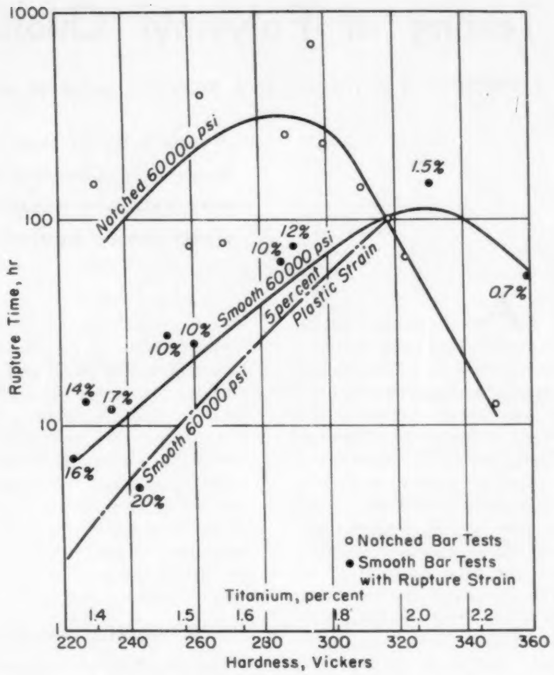

Fig. 2.—Tests of Discaloy Heats at 1200 F.

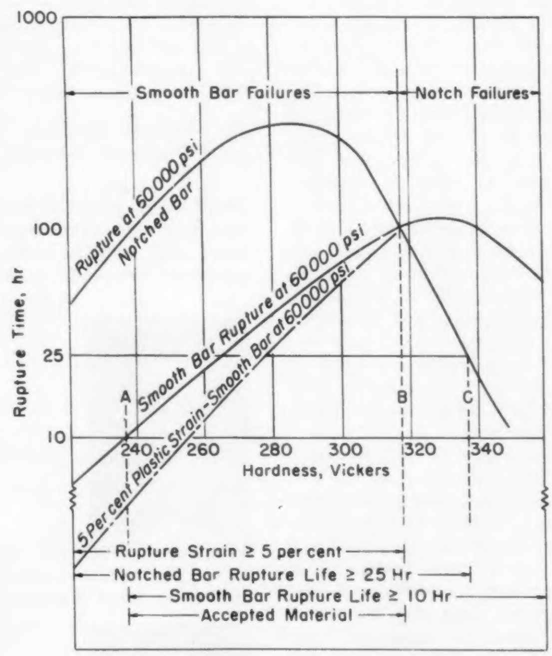

Fig. 3.—Tests of Discaloy Heats at 1200 F.

The Testing of Polyvinyl Chloride Electrical Formulations

By G. W. ASHWORTH, J. R. DARBY, W. E. KOERNER, and R. H. MUNCH

A new type of test specimen for studying resistivity during water immersion, obviates the time-consuming use of expensive, bulky wire-extrusion equipment—as little as 75 g of exploratory plasticizers can be studied

An increasingly important use of polyvinyl chloride formulations is in the field of electrical insulation. Insulated wire destined for use in home and commercial wiring in the United States must pass certain tests set up by the Underwriters' Laboratories in order to be given their approval.[1] Submission of wire samples insulated with a formulation for which Underwriters' Laboratories' official approval is sought is expensive and time consuming.

One of the important electrical tests which all TW rated formulations must pass is the 50 C water-immersion resistivity test. In order to pass this test in the minimum 12-week period, a sample of wire (usually 50 ft) immersed in water at 50 C must not exhibit a resistance of less than 10 megohms per 1000 ft of No. 14 wire with $\frac{1}{32}$-in. insulation during the entire test and in addition must not show an average resistance loss greater than 4 per cent per week during the poorest 3-week period during the latter half of the test. Less stringent absolute resistivity requirements and more stringent rate of change of resistivity requirements apply in an alternate 24-week test. Longer immersion periods are allowed if the absolute value of resistivity is satisfactory but the rate of change of resistance is too high. The dielectric constant of the formulation must also be measured as well as the change in this property after 1, 7, and 14 days of immersion in water at room temperature.

Although a sample of each proposed commercial formulation must be extruded on wire and submitted to the Underwriters' Laboratories for the official water immersion and dielectric constant tests, we were interested in developing a test method that would circumvent the need for expensive specialized extrusion equipment and would require a smaller sample for testing. Minimizing the amount of sample required was especially important when only moderate amounts of new exploratory plasticizers were available for testing or when possible plant process changes were evaluated in laboratory scale experiments. The poor correlation shown in Table I between water immersion test results and resistivity measurements on liquid plasticizer samples or dry slab resistivity measurements on formulations, required the development of a small simplified water-immersion test specimen.

The Molded Electrode Test Specimen

The requirements enumerated above led to the development of a molded electrode test specimen which consists essentially of a sheet of copper foil embedded in polyvinyl-chloride insulating compound (Fig. 1). This test specimen can be conveniently subjected to the 50 C water-immersion test. A tab of copper protrudes out of the test specimen to allow electrical connection to the copper foil above the immersion line so that the electrical resistance of the plastic composition can be measured. A roll mill (or Banbury mixer) and a molding press are the most important pieces of equipment required for the preparation of these samples. Most laboratories engaged in polymer or plasticizer evaluation and manufacturers of polyvinyl chloride insulated wire will have this equipment available. The time-consuming use of expensive extrusion equipment is completely avoided. The use of relatively small molded electrode specimens also results in reduced space requirements for test baths.

Using a roll mill or Banbury mixer, the formulation to be tested is prepared. A sheet about 40 mils thick is most convenient to use in the molding opera-

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[1] Standard for Thermoplastic-Insulated Wire, Underwriters' Laboratories, Inc., 161 6th Ave., New York 13, N. Y.

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GEORGE W. ASHWORTH, research chemist, has had 28 years' experience with process development, physical chemical measurements, and analytical methods development. He has worked extensively with plasticizers in each of these areas.

JOSEPH R. DARBY, group leader, has been in charge of plasticizer application research for the past ten years. He is an active member of ASTM Committee D-20.

WILLIAM E. KOERNER, group leader, is currently in charge of the electrical testing of plasticizers. He is actively engaged in a study of the factors affecting the electrical quality of plasticizers.

RALPH H. MUNCH, assistant research director, has had 20 years of broad experience with Monsanto in the areas of physical and analytical chemistry, spectroscopy, and instrumentation. He has guided numerous research efforts aimed at discovering the significant parameters governing the quality of organic chemicals for various end uses.

TABLE I.—CORRELATION OF LIQUID PLASTICIZER ELECTRICAL RESISTIVITY DRY SLAB RESISTIVITY, AND WATER-IMMERSION TEST PERFORMANCE USING MOLDED ELECTRODE TEST SPECIMENS.

Sample Designation	Specific Resistivity, megohm-cm						Underwriters' Per Cent Decrease
	Per Se 25 C	Dry Slab 50 C	Water Immersion				
			25 C	50 C			
			After 1 day	After 1 day	After 6 weeks	After 12 weeks	
DOP[a]— Sample A...	0.5×10^5	1560×10^5	2790×10^5	386×10^5	537×10^5	495×10^5	1.9
DOP— Sample B...	2.4	1650	2390	218	462	467	Increased
DOP— Sample C...	2.4	408	1008	72	56	61	Increased
DOP— Sample D...	2.9	3250	3055	433	1008	1008	0
DOP— Sample E...	11.4	1400	2720	409	544	480	2.3
DOP— Sample F...	13.4	2650	3590	515	1060	1060	0
DOP— Sample G...	18.4	1030	2580	370	760	612	3.7
DIOP[b]— Sample H...	0.4×10^5	833×10^5	2540×10^5	218×10^5	396×10^5	396×10^5	0
DIOP— Sample J....	1.4	2070	3260	511	361	254	7.0
DIOP— Sample K...	1.5	2630	3450	615	1018	1018	0
DIOP— Sample L...	1.8	638	1145	118	82	58	5.2
DIOP— Sample M...	3.3	991	1082	88	46	46	0
DIOP— Sample N...	5.2	1290	2240	218	335	295	3.1
DIDP[c]— Sample P...	0.8	694	2070	134	840	791	1.9
DIDP— Sample Q...	5.2	1990	2030	166	150	118	4.9
DIDP— Sample R...	14.0	1320	3500	285	649	700	Increased
DIDP— Sample S....	34.9	2430	4220	652	1412	1250	3.0

[a] di-2-ethylhexyl phthalate. [b] di-isooctyl phthalate. [c] di-isodecyl phthalate.

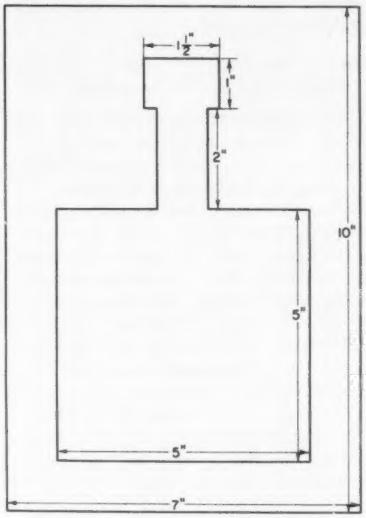

Fig. 2.—Molding Frame Design.

tion. The use of 75 g of plasticizer in a typical formulation (100 parts polyvinyl chloride, 50 parts plasticizer, 18 parts filler, plus stabilizer and lubricant) will yield enough material to prepare a 5 by 5 by 0.040-in. dry slab and two molded electrode test specimens. Molding frames of the shape and size shown in Fig. 2 are needed for the actual molding operation; two 32 mils thick and one 64 mils thick are most convenient. A copper-foil electrode of the size and shape shown in Fig. 3 is cut from a 6-mil sheet of half hard copper.[2,3]

Using a mold as a guide, two pieces are cut from the milled sheet. One cut sheet is placed in each 32-mil mold and molded under conditions of time, temperature, and pressure appropriate for the formulation being tested. Next, a piece of aluminum sheeting is placed beneath the 65-mil mold, one molded sheet placed in the mold, the copper electrode centered on the molded sheet,[4] the second molded sheet placed in the 65-mil mold and a piece of aluminum sheeting placed on top. Each side is covered with molding plates and the specimen molded under appropriate conditions. After the test specimen is extracted from the mold, it is placed between two sheets of aluminum foil to prevent contamination before it is placed in the water immersion test bath.

A similar technique involving the use of 1- by 6-in. foil electrode with a $\frac{1}{8}$-in. tab can be used to prepare molded electrode specimens suitable for dielectric constant tests. The small size of the sample permits direct molding of the finished test specimen from slabs cut from the roll mill sheet. The larger test specimens can be used equally well

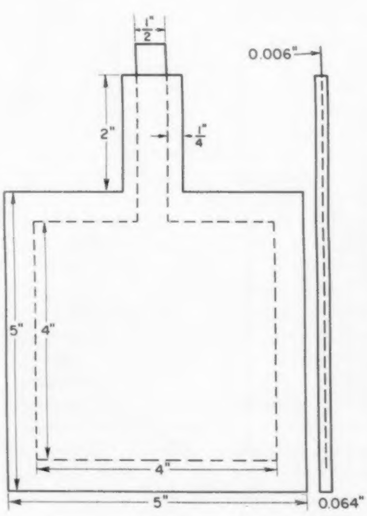

Fig. 1.—Molded-Electrode Test Specimen.

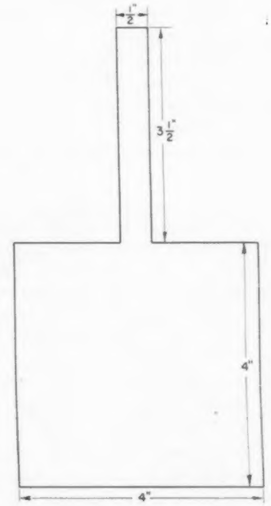

Fig. 3.—Copper Foil Design.

[2] Half-hard copper is used because dead-soft copper tends to follow the flow of the plastic in the molding operation and results in a higher percentage of rejects.

[3] The size of the electrode was chosen to result in resistivity values that were well within the range of our General Radio megohm bridge for even the best samples.

[4] An experiment in which the copper foil was cleaned with nitric acid before plastic sheets were molded around it produced results which did not differ significantly from the results obtained when the copper was not cleaned.

for this test if a suitable capacitance bridge is available.

Water Immersion Testing of the Molded-Electrode Specimen

Ten measurements of thickness are taken over the face of the molded electrode specimen and averaged. Subtracting the thickness of the copper foil from the average thickness and dividing the remainder by two gives the thickness of the insulating layer. To begin the water immersion test, the resistivity of the electrode sample is measured at the end of a 24-hr immersion period in 25 C water. The sample is transferred to the 50 C water bath, and resistivity measurements are made after 24 hr and at the end of each week for 12 weeks. The specific resistivity of the plastic coating of the sample is calculated according to the formula

$$R_s = \frac{AR}{t}$$

where:

R_s = volume resistivity in megohm-centimeters,
A = total area of immersed copper foil in square centimeters,
t = thickness of plastic layer in centimeters, and
R = measured resistivity in megohms.

The resistance which a 1000-ft length of wire insulated with this compound would have is calculated by dividing the specific resistance by the value of A/t for a 1000-ft length of No. 14 wire ($\frac{1}{32}$-in. insulation). The value is 2.76×10^5 cm. The resistivity values are plotted as a function of time and a smooth curve is drawn through the points. The behavior of this curve during the last six weeks of the test is used in computing the average per cent decrease in resistance per week during the worst 3-week period. To pass the Underwriters' test in 12 weeks, this value should be below 4 per cent per week if the sample has a resistivity greater than 10 megohms per 1000 ft of No. 14 wire. If the resistivity is between 0.1 and 10 megohms per 1000 ft of No. 14 wire, a 24-week test is required with a weekly average decrease of less than 2 per cent during the worst 3-week period in the last 12 weeks. The resistivity measurements can be conveniently made with a modified General Radio type 544-B megohm bridge. An external 4-decade resistance box covering the 1 to 999 ohm range was substituted for the decade slidewire in the bridge circuit. Other instruments capable of measuring high resistances accurately would be equally suitable.

TABLE II.—COMPARISON OF MOLDED-ELECTRODE TEST SPECIMENS PREPARED WITH BANBURY MIXER AND ROLL MILL.

Sample	Dry Slab, megohm-cm, 50 C	Water Immersion, Insulation Resistance, megohms per 1000 ft of No. 14 Wire				
		25 C, 24 hr	50 C			
			40 hr	1 week	7 weeks	12 weeks
Roll Mill						
Average $\bar{x}$	2.51×10^7	330	33	59	92	93
Standard Deviation σ	0.51	34	10	14	16	18
Banbury						
Average $\bar{x}$	2.30	340	33	57	88	90
Standard Deviation σ	0.51	41	12	16	10	13

All measurements were made 1 min after applying a bridge voltage of 500 v.

An insulated stainless steel bath with inside dimensions of 18 by 24 in. and 12 in. deep can be used to hold 12 sample jars 3 in. from the bottom of the bath on a removable stainless steel rack. The two ends of a demountable 3-in. wide stainless steel cross member are fastened to the centers of the 24-in. sides to provide a mount for the continuous duty stirrer, the thermoregulator, the heater, and a standardized thermometer (reading to 0.1 C). A 125-w heater will maintain the bath at 50.0 C if a thin layer of mineral oil is used to minimize water evaporation. The thermoregulator should control to within ±0.1 C. The liquid level in the bath is kept about ½ in. below the tops of the jars. The design details of the water immersion jars are shown in Fig. 4. A V-shaped piece of 1-in. stainless steel strip 3-in. in over-all length is used as a wedge between each jar and the rack to prevent movement of the jars which would cause oil to splash into the jars. This wedge also serves to keep empty jars from floating. The samples are supported from the cover by the use of short lengths of Nichrome wire which are pushed through holes pierced in the plastic tongue on both sides near the edge of the plastic. Ordinary tap water is used to fill the jars initially, but distilled water is added once a week to make up for that lost by evaporation. If some openings are not used, a small glass sheet can be placed over the unused slots to prevent excessive loss of water.

Care must be taken in manipulating the jars in the bath to prevent the oil floating on the surface of the water from contaminating the sample.

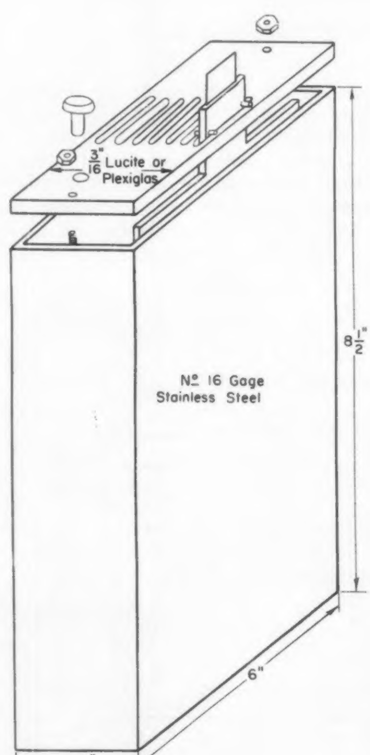

Fig. 4.—Water Immersion Vessel.

Studies of Variables in Preparation and Testing Technique

In studying alternate preparation techniques, the milling efficiency of a laboratory-size Banbury mixer and a roll mill were compared in a series of samples prepared from the same ingredients. Two samples were prepared by each method on each of three different days. The results summarized in Table II show that no great difference is to be expected if either of these two mixing techniques are used.

We also had observed that plastic slabs usually adhere to the foil whereas at least some extruded wire samples have an air film between the wire and the insulation. The results from a water immersion test of one electrode sample in which an air film was deliberately introduced between the foil and the slab were not different enough to suggest that this might cause serious variation in results.

Early observations also led to the sample segregation procedures presently used. No attempt had been made to

segregate samples in large water baths which were used initially for water immersion tests. When tricresyl phosphate - plasticized samples were included in a test group, cresols migrated from the tricresyl phosphate-plasticized samples to other samples. Samples prepared from the same plasticizer in the same formulation are generally tested together.

In conformity with Underwriters' Laboratories' practice, our present procedure does not provide for a continuous change of water because we too want to avoid the possibility of continuously leaching deleterious materials from the samples which could lead to deceptively high resistivity values.

Glass museum jars were used initially to segregate the samples, but they invariably chipped and cracked after several weeks use at 50 C.

Because the continuous application of a 600-v alternating potential prescribed in the Underwriters' test procedure is often omitted we eliminated this part of the test to avoid a very serious electric shock hazard.

Importance of Compounding Ingredient Uniformity

When the contribution of any ingredient to the electrical quality of a formulation is being studied, it is exceedingly important that the same lots of the other components in the formulation be used or that appropriate quality-control tests be applied to new lots of material. Wide variations in different lots of the same ingredient have been encountered which can obscure small variations in plasticizer quality which are being studied.

Correlation Tests

Fundamentally the same phenomena should be involved in the water-immersion testing of molded electrode samples and wire extrusions. The thickness of the plastic film is the same but the geometry is not identical. The thermal history of the two types of samples is similar, though not identical. A comparison was made using six different samples of polyvinyl chloride formulations.

Wire extrusions were made with extruder screw speeds of 12 and 40 rpm to test the effect of the varying exposure times in the extruder. A molded electrode sample was prepared from a sample of the bleeder stock from each extrusion. A portion of the extruder feed was also used to prepare a third molded electrode sample. The water-immersion test results for the 12 rpm wires and the corresponding molded electrode test specimens prepared from extruder feed are shown in Fig. 5. Similar results were obtained for the 40 rpm wires and the molded electrode test specimens from the bleeder stocks. The agreement between the results from the molded-electrode samples and the wire extrusions is very satisfactory especially in view of the fact that there is two hundred fold difference in resistivity between the poorest and best samples. This group of formulations involved a variety of different plasticizers, fillers, and stabilizers. In general, the changes in resistivity with time during the test were in good agreement. The only notable disagreement in rate of change of resistivity during the critical 6 to 12 week period was noted in samples D and E which represented different lots of the same formulation. This difference might be due to exceptional sensitivity of this formulation to mixing or thermal degradation. It is encouraging to note that the molded electrode specimens do show a smaller decrease or none at all, because this means that the inherent electrical excellence of a plasticizer may be discovered by this method. This information might then be used to indicate that a special study of extrusion conditions may be needed if wire extrusions do not approximate the molded electrode specimen results.

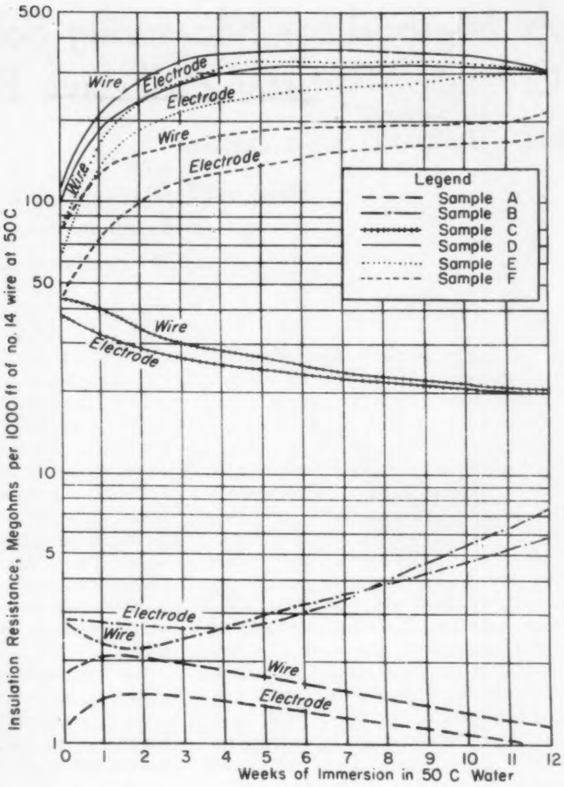

Fig. 5.—Comparison of Wire and Molded Electrode Test Specimen Results.

Conclusions

The correlation-data presented show that results obtained using molded electrode test specimens permit a good estimate of expected performance in wire extrusions. The small sample size and the relatively simple equipment requirements recommend this technique for the study and control of the electrical quality of other ingredients of polyvinyl chloride electrical formulations in addition to plasticizers. The poor correlation between water-immersion test results and the simpler liquid plasticizer and dry slab resistance measurements points up the need for more research effort on modifications of these desirably simple testing methods so that valid results can be obtained.

Acknowledgment:

Acknowledgment is made of the interest and assistance of Fred Locke and his colleagues in the Plastics Division of Monsanto Chemical Co. We are also indebted to Harry Gamrath, Roger Hatton, and Tracy Patrick, Jr., and many of their associates for preparing the numerous special plasticizer samples needed for this work. Elmer Cowell, Peter Spink, Paul Graham, and Robert Parks also contributed significantly in the development and preparation of the molded electrode specimens.

A Method for Measuring Solvent Resistance of Crystal-to-Crystal Adhesive Bonds

By B. J. FARADAY and D. J. G. GREGAN

Chief advantage of this method which has a wide range of application is the elimination of the supplementary mechanical tests required in the conventional method

LARGE-SIZED piezoelectric crystals with resonating characteristics satisfactory for use in sonar transducers have been produced at the Naval Research Laboratory by cementing two crystals together end to end, that is, butt-joining.[1,2,3] The research that led to this development was based on the necessity of extending the low-frequency limit of crystal transducers of conventional design currently employed by the Navy. In the crystal transducer used for efficient high-level sound generation, the operating frequency, at the fundamental resonance, is limited by the size (primarily the length dimension) of the crystal; and heretofore, there has been no commercial source of crystals which are large enough to resonate at the low frequencies desired.

A factor of primary importance in the fabrication of a butt-joined crystal transducer is the necessity of matching as closely as possible the frequency characteristics of each of the butt-joined units comprising a group, regardless of the position of the bond in each case. To facilitate assembly of crystal groups, the component crystals should have identical thickness and width dimensions. For these reasons, a bond once effected should be permanent despite any subsequent alteration of design or repair. A primary requisite of an adhesive to be employed in bonding together crystal adherends is its ability to resist the action of solvents customarily employed in the course of sonar transducer repair and maintenance operations.

One approach to the problem of determining the solvent resistance of adhesive bonds was provided by the ASTM Standard Method of Test for Resistance of Adhesive Bonds to Chemical Reagents.[4] In this test, the bonded specimen is immersed in a solvent for a period of seven days and is then subjected to one of various mechanical tests. In the event of a complete separation before the duration of the stipulated period, the immersion time would have to be shortened accordingly.

For the case of bonds which ultimately separated as a result of solvent action, an alternative procedure which eliminated the necessity of auxiliary mechanical tests was adopted. This resulted in an especially convenient way of investigating butt-joined ammonium dihydrogen phosphate (ADP) crystal plates inasmuch as the brittleness of this material effectively limits the number of mechanical tests that can be performed.

Testing Apparatus

The method of operation involved in the test is simple. A microswitch relay is held closed by the weight of a butt-joined crystal immersed in solvent. Separation of the bond reduces the weight on the microswitch causing the circuit to be opened. The time interval which elapses between the initial immersion and the ultimate separation serves as the measure of solvent resistance of the adhesive bond.

The apparatus employed in the test is pictured during actual operation in Fig. 1. The solvent in question was contained in a tank constructed by welding together rectangular sections of $\frac{1}{4}$-in. stainless-steel flat stock so as to form a box 14.25 in. long, 6.69 in. wide, and 3.12 in. high. The top edge of the tank walls was covered by a synthetic rubber gasket over which was placed a $\frac{1}{4}$-in. wire-mesh glass plate 16 in. long and 7.56 in. wide. The gasket and plate were bolted firmly to the tank in order to minimize the loss of solvent vapor. Right-angled 24ST aluminum brackets were mounted on the top surface of the plate as supports for eight identical testing units. One such unit was made up separately and is shown in Fig. 2. A microswitch was mounted on the bracket so that the pin plunger was in an upright position and supported an actuating lever (24ST aluminum). The lever in turn was connected to a stainless-steel clamp by a rod (0.186 in. in diameter) of the same material, which was threaded at each end and passed through a circular clearance hole (0.196 in. in diameter) in the glass plate. Two screws set in the clamp held the butt-joined crystal under test in a vertical position.

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D. J. G. GREGAN, a member of the Sound Division of the Naval Research Laboratory since 1947, has been engaged in the design and development of piezoelectric transducers to be incorporated into standard sonar equipment used by the Navy. For the past two years, he has performed research on the problem of crystal-to-crystal adhesive bonds.

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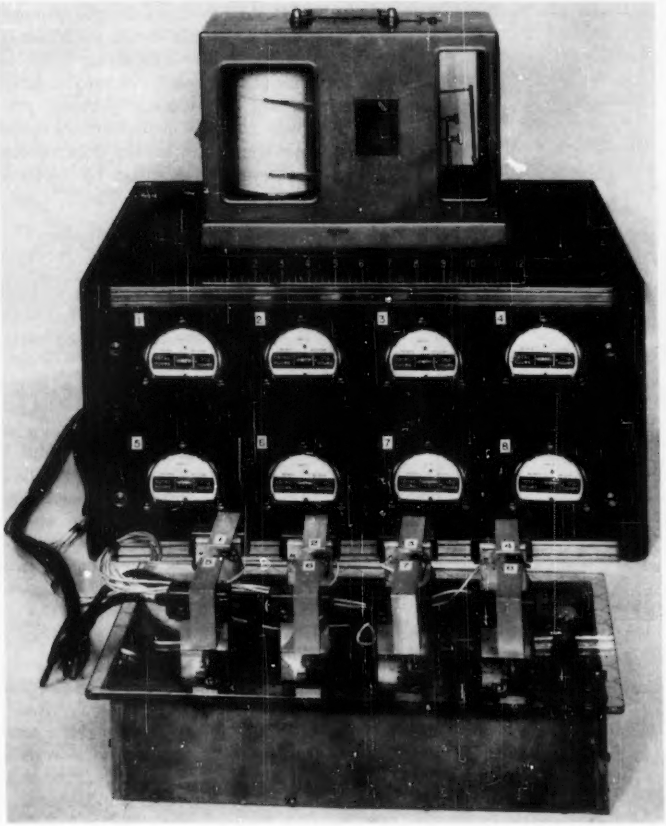
[1] B. J. Faraday and D. J. G. Gregan, *Progress Report*, Naval Research Lab., Oct., 1954, pp. 12–18.

[2] *Research Reviews*, Office of Naval Research, Oct., 1954 p. 23.

[3] B. J. Faraday and D. J. G. Gregan, *Journal*, Acoustical Soc. Am., Vol. 27, p. 1011 (Abst.) (1955).

[4] Method of Test for Resistance of Adhesive Bonds to Chemical Reagents (D 896 – 51), 1956 Book of ASTM Standards, Part 7, p. 1186.



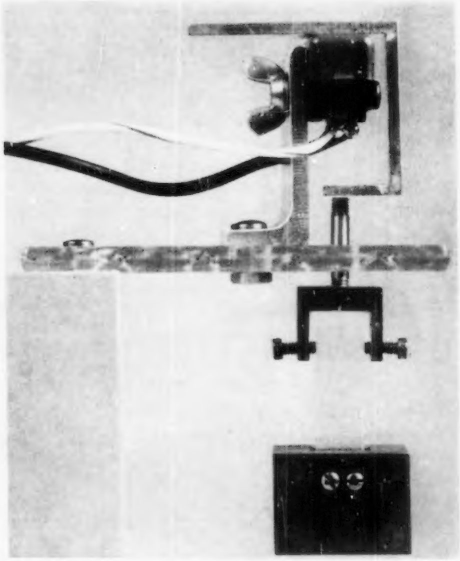


Fig. 2.—Separately Constructed Test Unit with ADP Butt-Joined Crystal in Place.

←

Fig. 1—Complete Apparatus for Solvent-Resistance Test. Tank Equipped with Eight Test Units in Foreground; Elapsed-Time Meter Panel and Temperature-Relative Humidity Recorder in Background.

The unit was designed so that the axes of the microswitch pin, the steel rod, and the clearance hole, respectively, and the center of gravity of the bonded crystal fell on the same straight line. The clearance of 0.010 in. between the rod and the plate was sufficient to minimize friction which might arise as a result of slight deviations in the balancing of the actuating lever arm with the load. A path was thereby provided for the escape of solvent vapor, although the resulting loss of solvent through evaporation never exceeded 3 per cent of the total volume.

The microswitch was part of a series circuit which also included an elapsed-time meter and a 110-v 60-cycle source. The type of microswitch chosen for the test remained in an open position until the pin supported a load greater than 0.314 lb; once the relay was closed, weight sufficient to reduce the load to 0.093 lb had to be removed in order to reopen the circuit. Since the weight in solvent of the lower ADP adherend, which was to drop to the bottom of the tank after separation of the bond, was negligible, an additional weight had to be attached. This took the form of a stainless-steel, hollow, symmetrical block weighing 0.374 lb, which was fastened to the lower adherend by four setscrews as shown in Fig. 2. The combined weight of the actuating lever, rod, clamp, setscrews, and upper ADP adherend, together with the weight in trichloroethylene of the lower adherend and block, was 0.392 lb, which sufficed to close the microswitch. After the bond separated and the lower adherend and block dropped off, the weight on the microswitch pin was reduced to 0.088 lb, thereby breaking the circuit.

The test procedure was straightforward. After each of the eight crystal units and blocks had been fastened to their respective clamps, the glass plate was bolted down at each corner. Solvent was then slowly poured into the tank through the $\frac{1}{2}$-in. filling hole in the plate to a level of about $\frac{1}{2}$ in. above the various glue lines being tested. Since the volume of adhesive material was negligible compared to that of the solvent, no provision for agitating the solvent was required. The initial reading of each elapsed-time meter was recorded, and no further maintenance was necessary until the last bond had separated. The difference between the reading of the stopped meter and the initial reading in each case was the time taken for the solvent to separate the bond. More accurately, the time elapsed represented the time required for the solvent to attack the adhesive bond to such a degree that it could no longer support a tensile stress equal to the weight in solvent of the steel block and lower adherend acting on the cross-sectional area of the bond. For the case reported below, the steel block described above was attached to an ADP adherend 0.50 in. wide and 0.25 in. thick. Accordingly, the stress on the bond was 2.432 psi. The temperature was maintained at 25 ± 1C and the relative humidity at 35 ± 5 per cent for the duration of the test.

Effect of Bond Thickness

Since the action of solvents on adhesive bonds is a surface phenomenon, the less surface which an adhesive exposes to a solvent, the greater should be its ability to resist attack. If one has a number of paired adherends having identical shape, and if each pair is bonded together along geometrically congruent surfaces and differs only in the thickness of the various glue lines, the test described above furnishes a convenient method of measuring the effect of the thickness of the bond on the solvent resistance of the adhesive.

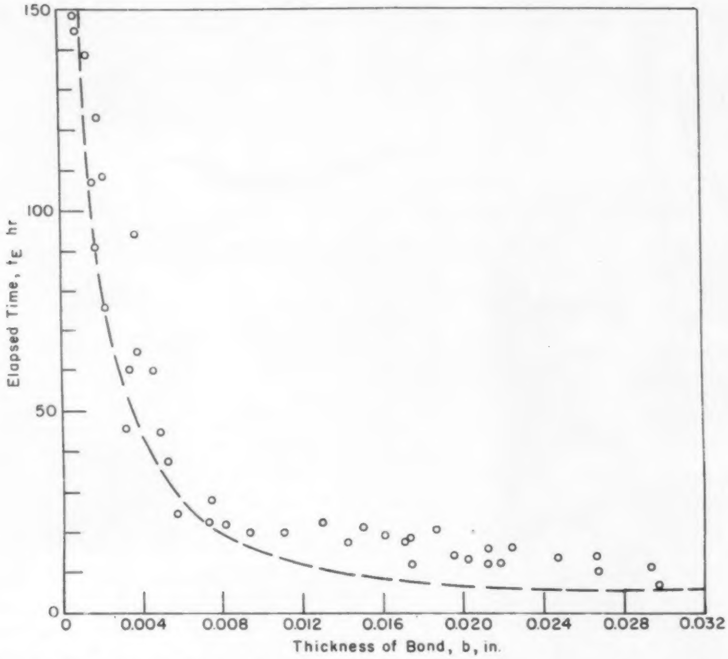


Fig. 3. Variation of Solvent Resistance with Bond Thickness for an Epoxide Resin Adhesive. The Curve Is a Plot of the Equation: $t_E = 200/b$.

Two adhesives were tested in this manner. Each ADP adherend was 1.12 in. long, 0.50 in. wide and 0.25 in. thick. In the first case an epoxide resin was employed as the bonding agent. The time interval elapsed from the initial immersion in trichloroethylene until the final bond separation, t_E, is plotted against the bond thickness, b, as shown in Fig. 3. A phenolic-elastomer adhesive was used for the second test and the same information is presented in Fig. 4.

In the interest of completeness, it is noted that the ADP adherends were machined to size by a single sweep cutting tool mounted in a vertical milling machine which had been adapted for high speed operation (4000 rpm). Particular care was taken in finishing the bonding surfaces so that the average height of irregularities from peaks to valleys did not exceed 150 microinches. The average bond thickness in each case was measured by means of a metallurgical microscope equipped with a Filar eyepiece micrometer.

Comparison of the two adhesives indicates that the epoxide resin is far superior to the phenolic-elastomer from the point of view of solvent resistance. In fact, if the solvent resistance is proportional to the elapsed time, as is assumed, the former is more resistant to trichloroethylene by a factor of about 12.5 for the range of bond thicknesses investigated.

Each adhesive shows a rapid decrease in solvent resistance as the thickness of the glue line increases from 0.001 to 0.008 in. (1 to 8 mils); for greater bond thicknesses, the decrease becomes progressively slower. A reasonably good fit with the experimental data of the two adhesives is obtained by plotting the relation

$$t_E = \frac{K}{b}$$

as is done in Figs. 3 and 4. That is to say, the solvent resistance is inversely proportional to the bond thickness. Here K is a constant which is a property of the adhesive material and of the solvent used, expressed in units of hour-mils if t_E is given in hours and b in mils. For the epoxide, $K \simeq 200$; for the phenolic-elastomer $K \simeq 16$. The type of behavior exhibited above is similar to that encountered in the experimental study of the mechanical strength of adhesive bonds.[5]

Additional Applications

There are few limitations as to the nature of the adherends which would make it impossible to use the above test for an investigation of solvent resistance. Extreme brittleness in the adherend material would impede satis-

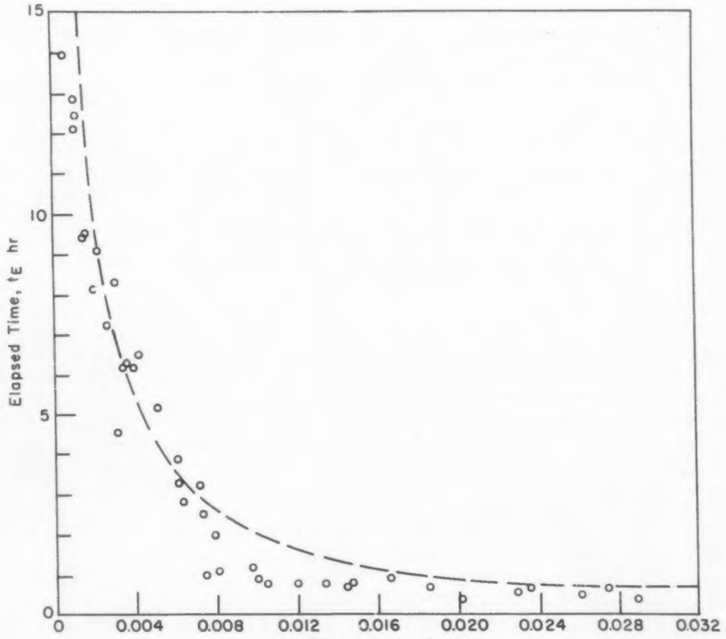


Fig. 4.—Variation of Solvent Resistance with Bond Thickness for a Phenolic-Elastomer Adhesive. The Curve Is a Plot of the Equation: $t_E = 16/b$.

[5] H. P. Meissner and G. H. Baldauf, *Transactions*, Am. Soc Mechanical Engrs., Vol. 73, pp. 697–704 (1951).

factory clamping. An adherend which lacked sufficient tensile strength to support the required weight could not be employed. Finally, if the adherend were more susceptible to solvent attack than the adhesive, this test would not apply. On the other hand, the test could readily be utilized to study such bond combinations as metal-to-metal, metal-to-glass, etc.

The test can be of particular value in the determination of the optimum conditions for the preparation and cure of the adhesive. It is of course understood that the optimum bonding conditions referred to pertain only to solvent sensitivity and not necessarily to mechanical properties like tensile strength, impact strength, fatigue, etc. This is particularly so in view of the fact that glue line thicknesses used for the solvent sensitivity determinations are far in excess of optimum for many adhesive systems. There are four principal variables in this case, namely, the bond thickness, the relative proportion of catalyst to cement, the time duration of the cure, and the curing temperature. By keeping the bond thickness and two of three remaining variables constant, the effect of changes in the fourth variable can readily be examined. It should be pointed out that in such a study a thick bond is far more preferable to a thin one since the spread in experimental data is far less in the former case as shown in Figs. 3 and 4.

As a final example of the adaptability of the test, the equipment used in the preceding work could be modified to investigate simultaneously the solvent resistance of an adhesive to different solvents. Each test unit could be mounted on separate glass plates in the manner shown in Fig. 2. Individual solvent containers of identical dimensions would then be fastened to the respective plates and filled with equal volumes of the solvents to be investigated. The weight attached to the lower adherend in each case would have to be adjusted separately so as to equalize the buoyant force exerted by each solvent. If the bond thickness were kept constant at some large value, as discussed above, then the effect of the various solvents could readily be determined.

Evaluation of a Microhardness Tester

By ROSS E. MORRIS and JOHN M. HOLLOWAY

Tests on rubber using an ISO instrument designed for specimens of odd size and shape gave satisfactory readings on specimens as thin as 1/64 in. or with a convex surface having a radius of 1/32 in.

THE service behavior of many types of small rubber items, particularly packings and gaskets, depends on the hardness of the rubber. It is customary to specify the durometer hardness value[1] for such small items even though it is practically impossible to make this measurement on the items themselves. It is generally assumed that the hardness of a small item is the same as the hardness of a larger, thicker block made from the same stock and given the same cure. These hardnesses, however, are not necessarily in agreement because of possible differences in state of cure and degree of anisotropy between the small item and the test block. Furthermore, the durometer is not the best instrument for the critical determination of hardness even on the test block because of the well-known subjective nature of measurements made with this instrument.

More reproducible readings from the standpoints of repeat measurements on the same specimen, measurements on replicate specimens, and measurements by different operators can be obtained by using the ASTM hardness tester.[2] This instrument has the three desirable features specified by Scott,[3] namely, a hemispherical indentor, a constant deadweight load acting on the indentor, and an annular pressure foot. The indentor, deadweight load and presser foot of the ASTM tester are, however, much too large and heavy to be used for measuring the hardness of small items, such as O-rings of $\frac{1}{8}$-in. cross-sectional diameter.

S. Oberto of the Pirelli Rubber Co., Milan (Italy) has designed a microhardness tester specifically for meas-

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JOHN M. HOLLOWAY, a rubber technologist at the Mare Island laboratory since 1946, was prior to that time products control supervisor in the rubber industry and is currently a director of the Rubber Division of the ACS.

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[1] Tentative Method of Test for Indentation of Rubber by Means of a Durometer (D 676 – 55 T), 1956 Book of ASTM Standards, Part 6, p. 1096.

[2] Tentative Method of Test for Hardness of Rubber (D 314 – 52 T), 1956 Book of ASTM Standards, Part 6, p. 1080.

[3] J. R. Scott, "Rubber Hardness Testing," *Rubber Age*, Vol. 77, July, 1955, p. 543.

[4] S. Oberto, "New Instruments for Measuring Hardness," *Rubber, Chemistry and Technology*, Vol. 28, p. 1054 (1955).

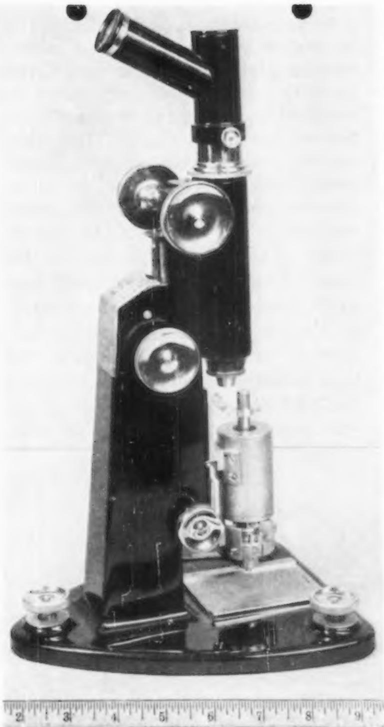

Fig. 1.—Photograph of Microhardness Tester.

uring the hardness of small rubber objects.[4] This hardness tester, which has the same three desirable features possessed by the ASTM tester, is being considered by the International Organization for Standardization (ISO). An instrument complying with Oberto's specifications is now being made by Nash & Thompson Ltd., Tolworth, Surrey (England). The purpose of the investigation reported here was to determine the suitability of this microhardness tester for measuring the hardness of small rubber items.

Description of Tester

A photograph of the microhardness tester is shown in Fig. 1. The instrument has the general appearance of a microscope except that the presser-foot assembly is substituted for the stage. An enlarged sketch of the presser-foot assembly is shown in Fig. 2.

Referring to Fig. 2, the following is the explanation of the operation of the presser-foot assembly. The tube *B* of the presser foot slides in the cylindrical box *A*. The lower end of the tube forms the presser foot *C*. The straight rigid rod *D* is the indentor rod, with a hardened polished ball of 0.4 mm ($\frac{1}{64}$ in.) diameter at its lower end acting as the indentor proper. The indentor load *E* has an annular form in its external part, which is lowered or raised by the annular support *F* fixed to the rack on the microscope column. The load is applied to the indentor through the platform *G*, which is rigidly connected to the rod itself. The cylindrical tube of the presser foot glides in the Teflon bearings *H*. The indentor rod glides through the Teflon bearings *I*. The upper extremity of the indentor rod *D* ends in a sharp point. The position of this point is observed through a window *J* on the upper end of the tube *B* by means of a small mirror held at a 45-deg angle and the microscope. The position of the point is measured on the reticle of the microscope, which is divided into 0.01-mm units, before and after lowering the indentor load *E*. Measurements can be made to the closest half division on the reticle (0.005 mm).

The weight acting on the presser foot is 29.44 g. The weight acting on the ball point of the indentor before lowering the measuring weight is 0.85 g. The additional load, which presses on the ball point of the indentor when measuring hardness, is 14.86 g.

Procedures Used for Evaluation

The microhardness tester was evaluated from three standpoints, namely, the sensitivity of the readings of the instrument to different hardnesses of rubber, the agreement between readings obtained on the same rubber in different shapes and sizes, and the agreement between repeat readings on the same specimen. It was felt that the microhardness tester should define hardness at least as distinctly as does the regular durometer. For example, there are ten distinct readings between 70 and 80 on the durometer scale. The microhardness tester, in order to have practical value, must also exhibit at least ten distinct readings between the respective readings on this instrument which correspond to 70 and 80 on the durometer scale. To be fully satisfactory for measuring the hardness of small items, the microhardness tester should give the same reading on small specimens as it does on large specimens of the same vulcanizate. The microhardness tester should give reproducible readings on specimens of all sizes.

Ten stocks ranging in durometer hardness from 35 to 81 were selected for this work. The hardnesses were measured 3 sec after pressing the durometer against the surface of the rubber. The stocks were compounded from Hevea smoked sheet, styrene-butadiene rubber, acrylonitrile-butadiene rubber and neoprene. The formulas of the stocks and the cures used are given in Table I. The spider-like composite specimen shown in Fig. 3 was molded from each of the stocks. The purpose of this specimen was to obtain a multitude of shapes and sizes of the same vulcanizate which would have essentially the same cure. The various individual specimens cut from the composite specimen had the following cross-sectional dimensions in inches: $\frac{1}{2}$ by 2 (diameter), $\frac{1}{8}$ by $\frac{1}{8}$, $\frac{1}{8}$ by $\frac{1}{4}$, $\frac{1}{16}$ by $\frac{1}{16}$, $\frac{1}{16}$ by $\frac{1}{8}$, $\frac{1}{16}$ by $\frac{1}{4}$, $\frac{1}{32}$ by $\frac{1}{16}$, $\frac{1}{32}$ by $\frac{1}{8}$, $\frac{1}{64}$ by $\frac{1}{16}$, $\frac{1}{64}$ by $\frac{1}{8}$, $\frac{1}{8}$ radius, $\frac{1}{16}$ radius, and $\frac{1}{32}$ radius. The latter three specimens were semicircular in cross-section. All curing was done at the relatively low temperature of 260 F in order to obtain a uniform and equal cure in these specimens of widely differing thicknesses cut from each composite specimen.

The sensitiveness of the readings of the microhardness tester to different hardnesses based on durometer readings was determined by making measurements with each instrument on the $\frac{1}{2}$-in. thick by 2-in. diameter specimens. Measurements were also made with the ASTM hardness tester and the Pusey and Jones plastometer.[5] Three-second readings were taken with the Shore A durometer, which had previously been standardized by the ASTM procedure.[1]

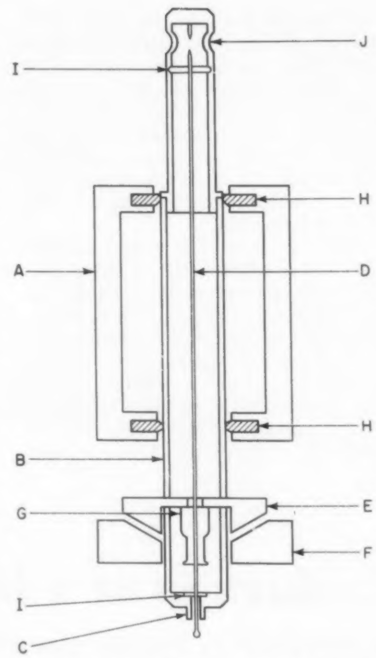

Fig. 2.—Sketch of Presser Foot Assembly.

[5] Method of Test for Indentation of Rubber by Means of the Pusey & Jones Plastometer (D 531 – 56), 1956 Book of ASTM Standards, Part 6, p. 1100.

TABLE I.—FORMULAS AND CURES OF STOCKS OF VARIOUS DUROMETER HARDNESSES.

35 Durometer	
Smoked sheet	100
Pelletex	2
Zinc oxide	5
Stearic acid	1
Heliozone	3
Califlux 510	3
Age Rite Resin D	1
Neozone D	1
Captax	0.5
Altax	0.5
Methyl Tuads	0.5
Sulfur	0.75
Cure: 68 min at 260 F	

45 Durometer	
Smoked sheet	100
P-33	35
Zinc oxide	5
Stearic acid	1
Heliozone	3
Age Rite Resin D	1
Captax	0.5
Altax	0.5
Methyl Tuads	0.5
Sulfur	0.75
Cure: 76 min at 260 F	

48 Durometer	
Paracril B	100
P-33	30
Statex B	30
Zinc oxide	5
Stearic acid	1
Heliozone	3
Plasticizer SC	5
KP-140	10
Captax	2
Methyl Tuads	3
Vandex	0.1
Cure: 152 min at 260 F	

50 Durometer	
GR-S 1000	60
GR-S 1009	40
Statex B	50
Zinc oxide	5
Heliozone	1
Flexol TOF	20
Santoflex AW	2
Methyl Tuads	1.5
Sulfur	1
Cure: 114 min at 260 F	

54 Durometer	
Paracril B	100
Pelletex	65
Zinc oxide	5
Stearic acid	1
Cumar P-10	30
Thionex	2
Sulfur	0.9
Cure: 190 min at 260 F	

57 Durometer	
Smoked sheet	100
Pelletex	20
Micronex	20
Zinc oxide	5
Stearic acid	2
Pine tar	2
RPA#2	0.2
Neozone D	1.5
Captax	1
Methyl Zimate	0.1
Sulfur	2.5
Cure: 152 min at 260 F	

67 Durometer	
GR-S 1000	100
Philblack A	34
Statex B	34
Zinc oxide	5
Heliozone	3
Califlux 510	10
Thionex	0.3
Sulfur	2
Cure: 190 min at 260 F	

73 Durometer	
Paracril B	100
Statex B	80
Zinc oxide	5
Stearic acid	1
Cumar P-10	5
Bardol B	5
Thionex	0.3
Sulfur	1.4
Cure: 228 min at 260 F	

77 Durometer	
Paracril B	100
Statex B	100
Zinc oxide	5
Stearic acid	1
Heliozone	3
Plasticizer SC	10
KP-140	10
Thionex	0.3
Sulfur	7
Cure: 190 min at 260 F	

81 Durometer	
Neoprene GN	100
Pelletex	90
Zinc oxide	5
XLC Magnesia	4
Stearic acid	1
Petrolatum	2
Circo L.P. oil	6.2
Neozone A	2
Sodium acetate	1
Cure: 152 minutes at 260 F	

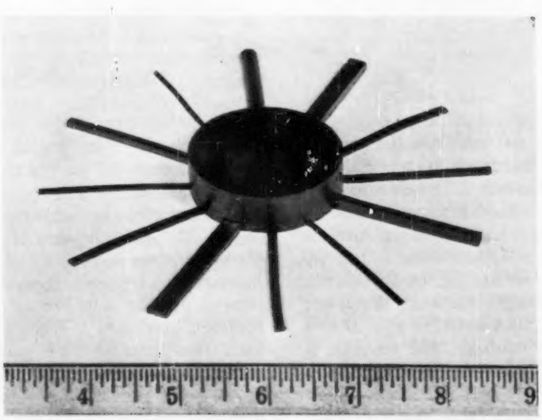

Fig. 3.—Photograph of Composite Test Specimen.

Thirty-second readings were taken with the ASTM hardness tester[2] and the microhardness tester, and 60-sec readings were taken with the Pusey & Jones plastometer.[5] Sufficient readings were taken with the respective instruments on each of the 10 specimens to insure that the correct values were being recorded. All measurements were made at 73.5 ± 2 F. The data are given in Table II and are plotted in Figs. 4, 5, and 6. Only the curve for the 14.86-g indentor load in Fig. 4 should be considered at this time.

Comparison of Hardness Testers

A smooth curve has been drawn in Fig. 4 to represent the relation between the readings on the microhardness tester and the corresponding readings on the durometer. The experimental points at the lower part of this curve (14.8 g load), however, are somewhat scattered, so the location of the curve in this region is a matter of conjecture. This rather indefinite relationship between the readings of the two instruments is due partly to the subjective nature of the measurements with the spring-operated durometer, but is mostly due to the viscoelastic nature of rubber. The 3-sec reading on the durometer is more influenced by the viscosity of the rubber than is the 30-sec reading on the microhardness tester.

The curves in Figs. 5 and 6 show that a clear-cut relationship exists between the readings of the microhardness tester on the one hand and the readings of the ASTM hardness tester[2] and the Pusey & Jones plastometer[5] on

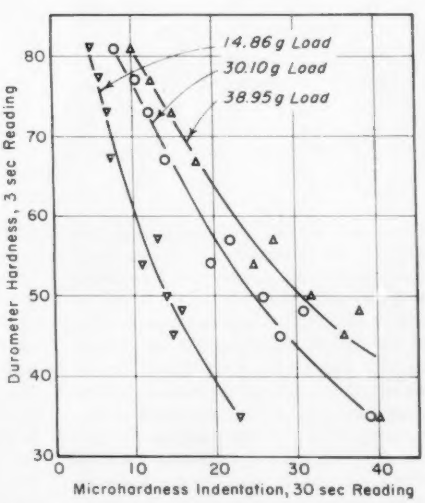

Fig. 4.—Plot of Microhardness *versus* Durometer Hardness with Various Loads on Indentor of Microhardness Tester.

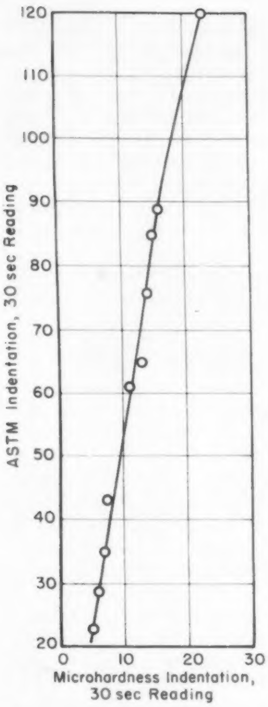

Fig. 5.—Plot of Microhardness *versus* ASTM Hardness with Standard Load on Indentor of Microhardness Tester.

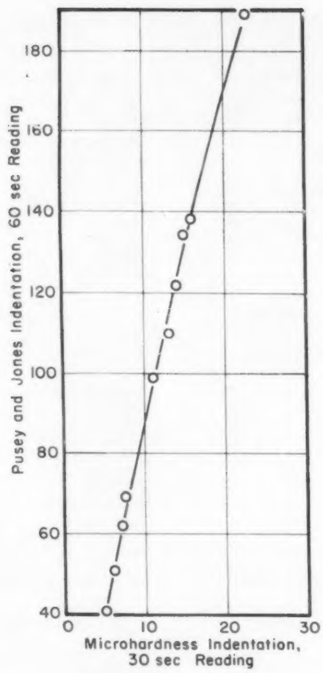

Fig. 6.—Plot of Microhardness *versus* Pusey and Jones Hardness with Standard Load on Indentor of Microhardness Tester.

TABLE II.—COMPARISON OF HARDNESS READINGS MADE WITH VARIOUS INSTRUMENTS.

Durometer 3-sec reading	ASTM Hardness Tester 30-sec reading	Pusey & Jones Plastometer 60-sec reading	Microhardness Tester 30-sec reading using indentor load of		
			14.86 g (standard)	30.10 g	38.95 g
35	120	189	23	39	40
45	85	134	15	28	36
48	89	138	16	31	38
50	76	122	14	26	32
54	61	99	11	19.5	25
57	65	110	13	22	27.5
67	43	69	7.5	14	18
73	35	62	7	12	15
77	29	51	6	10.5	12.5
81	23	41	5	8	10

the other hand. This was expected because the indentors of all of these instruments are acted upon by dead weights, and relatively long periods of weight application are employed. The 30- or 60-sec intervals for subjecting the indentor to the dead weight before taking the readings on these instruments are long enough for most of the viscosity effect on the readings to disappear. Thus, these hardness readings reflect essentially the elastic force of the rubber.

Returning to Fig. 4, examination of the curve for the standard weight (14.86 g.) shows that between the 70 and 80 durometer readings the reading of the microhardness tester changed by only 2 divisions. This means that in this range the durometer has 10 readable units while the microhardness tester has only 4, and thus is not an acceptable substitute for the durometer. The curve changes slope at the lower hardnesses so that between the 40 and 50 durometer readings, the reading of the microhardness tester changed by $5\frac{1}{2}$ divisions or 11 readable units, which is adequate. But most small gaskets and packings on which the microhardness tester would be used are in the upper range of hardness. A change should be made in the microhardness tester, if possible, to increase its sensitivity at higher hardness values.

Increasing Sensitivity of Instrument

Three alterations which could be made in the microhardness tester to improve its sensitivity were considered. They were: (1) increasing the magnifying power of the microscope so that the readings could be taken to the closest tenth division (0.001 mm) instead of the closest half division, (2) reducing the size of the indentor point so that the present load would cause a greater indentation in a given rubber, and (3) increasing the load so that the present indentor point would cause a greater indentation in a given rubber. Only the last of these possible alterations was deemed to be practical. Increasing the magnifying power of the microscope would reduce its field; the entire scale of the reticle would no longer be visible. This would restrict the instrument to measurements in a narrow hardness range. Reducing the size of the indentor point to a reproducible, polished hardened ball smaller than 0.4 mm in diameter would be an extremely difficult operation, and probably beyond present techniques.

Two brass rings were made for trial as additional indentor loads. They were split so that they could be positioned on the existing indentor load (*E* in Fig. 2). The relationship between the various total indentor loads is given below:

Type	Total Indentation Load, g.	Increase over Standard Indentor Load, per cent
Standard	14.86	0
First experimental	30.10	102.6
Second experimental	38.95	162.1

The sensitivity of the microhardness tester when operating with the respective experimental indentor loads was determined as previously done. The results are given in Table II and plotted in Fig. 4. Examination of the curves shows that the sensitivity of the microhardness tester was considerably improved in the range of 70 to 80 durometer hardness. With the 30.10-g load the span of the microhardness tester was 5 divisions or 10 readable units; with the 38.95-g load the span was $5\frac{1}{2}$ divisions or 11 readable units. It is therefore concluded that the micro-

TABLE III.—MICROHARDNESS OF VARIOUS VULCANIZATES IN VARIOUS SHAPES AND SIZES.

Durometer Hardness	Microhardness Indentation using indentor load of 14.86 g for specimens of following cross sections (thickness by width, in.).												
½ by 2 specimen	½ by 2	⅛ by ⅛	⅛ by ¼	1/16 by 1/16	1/16 by ⅛	1/16 by ¼	1/32 by 1/16	1/32 by ⅛	1/64 by 1/16	1/64 by ⅛	⅛ rad by ¼	1/16 rad by ⅛	1/32 rad by 1/16
35	23	22.5	23.5	23.5	22.5	22.5	21.5	21	18.5	19	23.5	23.5	23
45	15	15.5	15	15.5	14.5	14.5	14.5	14.5	14	13.5	14.5	15	16
48	16	15	15	14.5	15	14.5	14	14	13	13	15	14	14.5
50	14	14	13.5	14	14	13.5	13.5	13.5	12.5	12.5	14	14.5	14
54	11	10	10.5	10.5	12	10.5	10.5	10.5	10.5	10.5	10.5	11	11.5
57	13	12	12.5	12.5	12	12	11.5	12	10	10	12	12.5	12
67	7.5	7.5	8.5	8	8	8	8	8	8	8	8	8.5	8.5
73	7	6	6	5.5	7	6	5.5	5.5	5.5	5.5	6	5.5	6.5
77	6	5.5	5.5	6	5.5	6	5.5	5.5	5.5	5.5	5.5	6	6
81	5	4	4.5	4	4	4.5	4	4	4	4	4	4	5

hardness tester can be made to be at least as sensitive as the durometer in the higher hardness range by increasing the indentor load about 100 per cent over the present design.

Effect of Size and Shape of Specimen

The measurements made on the specimens of various shapes and sizes cut from the composite specimen are given in Table III. The standard indentor load was used. Special care was taken to insure that the indentor point came in contact with the rubber at the apex of those specimens having a semicircular cross-section and at the center of the other specimens. Fair agreement was obtained between the measurements on the different specimens, even for measurements on specimens having a semicircular cross-section with $\frac{1}{32}$ in. radius. However, there was a tendency for the indentation to decrease with thinner specimens. The difference between the indentations on the $\frac{1}{2}$ in. thick specimens and those on the corresponding $\frac{1}{64}$-in. thick specimens amounted to about 20 per cent for the softer vulcanizates. The reduced indentation in the thin specimens was due, of course, to the smaller volume of rubber between the indentor and the metal plate which supported the specimen. The variation between indentations obtained on thick and thin specimens of the same rubber would not necessarily be disadvantageous for purposes of specification testing or control testing, since indentation requirements could be established for the particular thickness of rubber being tested.

Table IV shows that the effect of specimen thickness on the indentation was somewhat greater when the indentor load was increased. The $\frac{1}{2}$ by 2-in. specimen and the $\frac{1}{64}$ by $\frac{1}{8}$-in. specimen were used for these tests.

TABLE IV.—MICROHARDNESS OF VARIOUS VULCANIZATES IN ½-IN. AND 1/64-IN. THICKNESSES USING DIFFERENT INDENTOR LOADS.

Durometer Hardness	Microhardness Indentation					
	14.86-g Indentor Load (standard)		30.10-g Indentor Load		39.95-g Indentor Load	
½ in. specimen	½ in. specimen	1/64 in. specimen	½ in. specimen	1/64 in. specimen	½ in. specimen	1/64 in. specimen
35	22	19	42	30.5	43	36
45	15	13.5	28.5	23	36	29
48	17	13	30.5	23	37	27
50	14.5	13	26.5	21	33	26
54	10	10	19.5	18	23.5	20.5
57	13	11	23	19	28	21
67	7.5	7	14	13	18	16
73	6	6	12	9.5	15	12
77	5.5	5.5	10	10.5	13	11.5
81	4.5	4	8.5	7	10	10

TABLE V.—RESULTS OF REPEAT TESTS ON VARIOUS SPECIMENS USING MICROHARDNESS TESTER.

Specimen	Durometer Hardness of Stock Used	Microhardness Indentation (using standard indentor load) as obtained in series of repeat tests
Block, ½ in. thick by 2 in. diam.	36	22.5, 22, 22, 22, 22, 22, 22.5, 22, 22, 22
O-ring, 0.139 in. diam.	36	23, 23, 23, 23, 23, 23, 23, 23, 23, 23
V-ring, 0.039 in. thick[a]	36	22.5, 23, 23, 23, 22.5, 23, 23, 23, 23, 23
Block, ½ in. thick by 2 in. diam.	56	11, 11, 12, 12, 12, 12, 12, 12, 12, 12
Block, ½ in. thick by 2 in. diam.	73	7, 7.5, 7, 7, 7, 7, 7, 8, 8, 7
O-ring, 0.139 in. diam.	73	7, 8, 7, 7, 7, 7, 7, 7, 7, 7
V-ring, 0.039 in. thick[a]	73	7.5, 7, 7, 7, 7.5, 7, 7, 7, 7, 7

[a] Thickness at point of measurement, see Fig. 7.

Reproducibility of Test Results

Table V shows the results of repeat tests by the same operator on blocks, O-rings and V-rings of different hardnesses. The small variation found within all but one series of results could have been due to minor differences within each rubber specimen as well as to differences in the operation of the tester. The O-rings were not held in a mandrel while being tested; they were merely supported on a flat surface and manipulated so that the indentor contacted the uppermost surface of the ring. The V-rings were supported on a mandrel while being tested, as shown in Fig. 7.

It is noteworthy that the microhardness tester gave satisfactory results from the standpoint of reproducibility on specimens having a convex surface, that is, O-rings, V-rings, and specimens of semicircular cross-section. It probably would also give satisfactory results on a concave surface, providing that the concavity were not so severe that the presser foot tended to bridge so that it was not entirely in contact with the rubber.

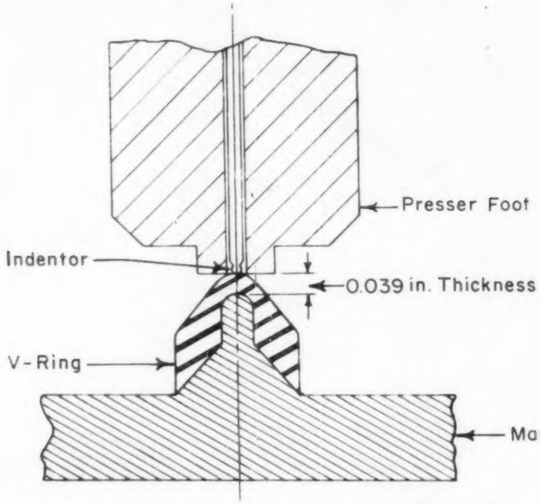

Fig. 7.—Cross-Section of Assembly for Measuring Microhardness of V-ring.

Summary

To summarize, it has been found that:

1. The microhardness tester, as designed, is not as sensitive as the durometer for the higher hardnesses of rubber, but is more sensitive for the lower hardnesses.

2. The sensitivity for higher hardnesses can be made equal to, or better than, that of the durometer by increasing the load on the indentor.

3. The readings of the microhardness tester tend to become progressively lower when the thickness of the specimen is reduced. This behavior is most pronounced when testing soft rubbers. The instrument, however, can be used to determine the hardness of specimens as thin as $\frac{1}{64}$ in.

4. The reproducibility of readings is satisfactory on all surfaces including convex surfaces having a radius as small as $\frac{1}{32}$ in.

Acknowledgment:

The authors wish to express their appreciation to T. A. Werkenthin of the Bureau of Ships for his interest in this investigation.

The opinions or assertions contained in this article are those of the authors and are not to be construed as official or reflecting the view of the Navy Dept. or the Naval service at large. This paper was presented at the 70th Meeting of the Division of Rubber Chemistry, Am. Chemical Soc., in Atlantic City, N. J., Sept. 1956.

FEDERAL GOVERNMENT STANDARDS INDEX CHANGES

The General Services Administration of the Federal Supply Service is charged with the responsibility for establishing specifications to be used by the Federal Government for procurement of materials and supplies. The GSA issues an annual Index of Initiation of Federal Specifications and Federal Standards Projects, and monthly supplements.

The items listed below include all changes since Supplement No. 11 of January, 1957, and were taken from the GSA Report on Federal Standards Projects dated March 1, 1957.

INITIATIONS:

Title	Type of Action	Symbol or Number	FSC Code	FSSC Class	Assigned Agency & Preparing Activity
Anodes, Nickel	New	QQ-A-677	3426	..	DOD-Army-Ord.
Benzene (Benzol), Technical	Rev.	VV-B-00231b	6810	..	GSA-FSS
Brazing Alloy, Gold	New	QQ-B-653	6520	57	GSA-FSS
Calcium Sulfate; Anhydrous (For Drying and Desiccating Purposes)	Rev.	L-C-169	9330	..	GSA-FSS
Cellulose Acetate Plastic Sheets	Am. 1	O-C-136b	6810	..	DOD-Army-CE
Cleaning Compound, Synthetic Detergent, Non-Abrasive, All-Purpose	Rev.	P-C-00431b	7930	51	GSA-FSS
Containers, Folding, Corrugated, Fiberboard (For Household Goods)	Rev.	PPP-C-570	8115	..	DOD-Army-QMC
Fencing (Barbed Wire, Woven Wire, and Wire Netting)	Am. 2	RR-F-221	5560	..	GSA-FSS
Pipe, Clay (Perforated)	New	SS-P-00359	5630	..	GSA-FSS
Solvent, Volatile Mineral Spirits	New	TT-S-570	8010	52	DOD-Navy-Ord.

PROMULGATIONS:

Title	Type of Action	Symbol or Number
Preservation, Packaging, and Packing Levels (Superseding Int. Fed. Std. No. 00102(GSA-FSS)	..	Fed. Std. No. 102
Belting; Flat, Leather, Vegetable-Tanned	Am. 1	KK-B-201c
Plastic Sheet, Modified Unplasticized-Polyvinyl Chloride, Rigid	Am. 1	L-P-510

INTERIM FEDERAL SPECIFICATIONS ISSUED:

Title	Type of Action	Symbol or Number
Antifreeze, Ethylene Glycol, Inhibited	New	O-A-00548(GSA-FSS)
Benzene (Benzol), Industrial	Rev.	VV-B-00231b(GSA-FSS)
Cellulose Acetate Plastics Sheets	Int. Am.1	L-C-169(GSA-FSS)
Cleaning Compound, Synthetic Detergent-(Non-Abrasive)	Rev. 1	P-C-00431b(GSA-FSS)
Sealing Compound; Cold-Application Ready-Mixed Liquefier Type, for Joints in Concrete	New	SS-S-00158(COM-BPR)

SPECIFICATIONS AND STANDARDS APPROVED FOR PRINTING:

Title	Type of Action	Symbol or Number
Tolerances for Aluminum Alloy and Magnesium Alloy Wrought Products	New	Fed. Std. 245
Aluminum-Alloy Forgings, Heat-Treated	Am. 1	QQ-A-367d
Aluminum and Aluminum Alloy Wrought Products, Tolerances For	Canc.	QQ-A-245

PERSONALS...

News items concerning the activities of our members will be welcomed for inclusion in this column.

NOTE—*These "Personals" are arranged in order of alphabetical sequence of the names. Frequently two or more members may be referred to in the same note, in which case the first one named is used as a key letter. It is believed that this arrangement will facilitate reference to the news about members.*

At the 61st Annual Meeting of the American Foundrymen's Society in Cincinnati last month, **Harry W. Dietert,** chairman of the board, Harry W. Dietert Co., Detroit, Mich., was elected AFA President. **Hyman Bornstein,** retired manager, Materials Engineering Dept., Caterpillar Tractor Co., Moline, Ill., delivered the 1957 Hoyt Memorial Lecture "Progress in Iron Castings." **Charles C. Donoho,** chief metallurgist, American Cast Iron Pipe Co., Birmingham, Ala., was awarded the Peter L. Simpson Gold Medal "for outstanding contributions to the Society and to the ferrous castings industry, especially in the fields of gray iron, nodular iron and steel." **Arthur E. Schuh,** director of research and development, United States Pipe and Foundry Co., Burlington, N. J., was one of the first four men to be honored by AFS with Awards of Scientific Merit. Mr. Schuh was recognized "for conscientious effort in AFS cupola research investigations and in development of the Society's basic ferrous publications, 'The Cupola and Its Operation.'" **Thomas E. Barlow,** sales manager, Eastern Clay Products Dept., International Minerals and Chemicals Corp., Chicago, Ill., was one of three receiving Service Citation Awards, also presented for the first time by AFS this year, and intended exclusively as recognition for outstanding general service, primarily of a nontechnical nature, to the Society and the castings industry. Mr. Barlow's award recognized "unstinting service to the Society and its Chapters as a speaker on Molding Sands and Cupola Operations, and for his ready willingness to serve whenever called upon."

A number of ASTM members and committee members were among those honored at the meeting of the American Welding Society in Philadelphia in April. **Harry E. Rockefeller,** manager, electric welding, Linde Air Products Co., New York City, was elected treasurer. **Robert M. Wilson, Jr.,** welding specialist, Development and Research Div., International Nickel Co., New York City, and **Sidney Low,** supervising engineer, Research and Development Lab., Chapman Valve Manufacturing Co., Indian Orchard, Mass., are among new directors-at-large. **Fred L. Plummer,** director of engineering, Hammond Iron Works, Warren, Pa., was named winner of the Samuel Wylie Miller Memorial Award, presented for outstanding contributions in the application of welding to storage tanks and to the advancement of engineering technology in the shop and field fabrication of welded structures. This year's Adams Lecturer was **DeWitt C. Smith,** chief metallurgist, Harnischfeger Corp., Milwaukee, Wis., who presented a special paper on the subject of the welding of ultra-high-strength steels. This lecture is named after the founder and first president of AWS, **Comfort A. Adams,** who was honored at a banquet at the Hotel Sheraton on April 8. Dr. Adams, 88-year-old Philadelphia engineer, was presented a portrait of himself by **Harry W. Pierce,** past-president of AWS and vice-chairman of the board of directors of New York Shipbuilding Corp., Camden. Honorary membership was awarded **O. B. J. Fraser,** assistant manager, Development and Research Div., International Nickel Co., New York City. The National Meritorious Service Award went to **A. N. Kugler,** chief welding engineer, Air Reduction Sales Co., New York City, for outstanding service rendered AWS for many years.

Roger G. Bates, leader of the National Bureau of Standards' pH standardization program and well-known authority on pH measurement, has been awarded the Department of Commerce Gold Medal for Exceptional Service. The award recognizes his "outstanding contributions to the science of hydrogen-ion measurements in theory and practice and for highly distinguished authorship."

Stephen W. Benedict has been elected executive vice-president of the Master Builders Co., Div. of American Marietta Co., Cleveland, Ohio. He joined Master Builders in 1948 as director of research, and has been vice-president of research and engineering since 1955.

Members of Committee A-5 on Corrosion of Iron and Steel, and other of the ferrous committees on which **W. Earle Buck** had served, will be interested in a note recently received from him expressing regret that he could not continue his Society and Committee contacts because of poor health. Until his retirement a year or so ago Mr. Buck had been for a long period with Continental Steel Co.; in earlier years had been associated with Granite City Steel Co. He resides at 3710 Pine Grove Ave., St. Louis, Mo. His son, **Robert H. Buck,** with Monsanto Chemical Co., also is a member of ASTM.

Sumner E. Campbell is again with Macmillan Petroleum Corp., Long Beach, Calif., as director of research. He was for some time with Palomar Oil & Refining Corp., Bakersfield.

M. B. Chittick recently retired from American Mineral Spirits Co., Murray Hill, N. J. Col. Chittick is continuing his ASTM affiliation.

R. Hunter Dunn, formerly with Precast Haydite, Ltd., Toronto, is now manager, Aerocrete Construction Co., Ltd., Montreal, Canada.

F. Burrows Esty, chief engineer, Wisconsin Motor Corp., Milwaukee, Wis., was elected a vice-president of his company.

J. B. Evans recently retired as rubber chemist, Westinghouse Air Brake Co., Wilmerding, Pa.

Charles O. Heath, Jr., until recently assistant professor, Oregon State College, Corvallis, Ore., is on the faculty of the University of Roorkee, Roorkee, U. P., India.

K. B. Hirashima, formerly materials testing engineer, Territorial Highway Dept., Hawaii, has opened offices as consulting engineer, 943 S. Queen St., Honolulu.

J. O. Jackson has retired as manager, Engineering Dept., Pittsburgh-Des Moines Steel Co., Pittsburgh, Pa.

A. G. Johnson, chief engineer, Omaha Public Power District, has been nominated for the office of vice-president of North Central District (No. 6) of the American Institute of Electrical Engineers.

Malcolm F. Judkins has been named director, new product development, Firth-Sterling, Inc. Until recently he had been chief engineer, high-temperature alloys division.

F. A. Lowenheim has been appointed technical advisor to **C. K. Banks,** vice-president of research and development, Metal and Thermit Corp., Rahway, N. J. Dr. Lowenheim has been with the company since 1936 as a research chemist and research supervisor.

Jack L. Marley, formerly with General Electric Co., Knolls Atomic Power Lab., Schenectady, N. Y., is now associated with the Nuclear Materials and Equipment Corp., Apollo, Pa.

B. R. Nijhawan, for some time acting director, has been appointed director of the National Metallurgical Laboratory, Council of Scientific and Industrial Research, Jamshedpur, India. Dr. Nijhawan also recently was elected a Fellow of the National Institute of Sciences of India.

Carl J. Oxford, Jr., until recently research engineer, has been named director of research, National Twist Drill and Tool Co., Rochester, Mich.

Frank W. Reinhart, chief of the plastics section at the National Bureau of Standards, has been awarded the Department of

(*Continued on page 56*)

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Personals

(*Continued from page 51*)

Commerce Silver Medal for Meritorious Service. The award recognized his "major contributions to the science and technology of plastics, and highly distinguished authorship." Mr. Reinhart currently is chairman of ASTM Committee D-20 on Plastics. He also served for four years as chairman of ASTM Committee D-14 on Adhesives.

Ralph Rose, formerly research engineer, E. J. Lavino and Co., Norristown, Pa., is now associated with Laclede-Christy Co., Div. of H. K. Porter Co., Inc., St. Louis, Mo.

Roman Smoluchowski, professor of physics and metallurgical engineering, Carnegie Institute of Technology, Pittsburgh, Pa., has been invited to give a series of lectures in July at the International Summer School on Solids in Varenna, Italy. Internationally known for his work in solid state physics and physics of metals, Dr. Smoluchowski has been working for over five years on the effects of irradiation in atomic reactors. This work has been under a contract with the Atomic Energy Commission.

David B. Steinman, of New York City and Miami, internationally famous engineer and designer of more than 400 bridges, was honored recently by the University of Florida, Gainesville, by dedication of the Steinman Lounge for its faculty. The recipient of numerous awards and honors, Dr. Steinman received last month, for the second time in 16 years, the J. Lloyd Kimbrough Medal of the American Institute of Steel Constructions. He also was given the honorary degree of doctor of humanities at Florida Southern College's 72nd Convocation in April.

Stephen Teleshak, formerly manager, metallurgical dept., Pittsburgh Testing Laboratory, Pittsburgh, Pa., is now associated with United Engineering and Foundry Co., Vandergrift, Pa.

A. J. Williamson, until recently vice-president, has been elected president, Tube Reducing Corp., Wallington, N. J.

DEATHS...

A. R. Carr, dean, College of Engineering, Wayne University, Detroit, Mich. (June, 1956). Representative of University membership since 1951.

J. H. Crawford, dean of engineering, Merrimack College, North Andover, Mass. (February, 1957). Representative of College membership since 1954.

Duncan P. Forbes, president, Gunite Foundries Corp., Rockford, Ill. Member of Society since 1942, serving for many years on Committees A-3 on Cast Iron and A-7 on Malleable-Iron Castings.

E. D. Johnson, assistant city engineer, City of Muskegon (Mich.) Engineering Dept. (February 16, 1957). Representative of City membership since 1949.

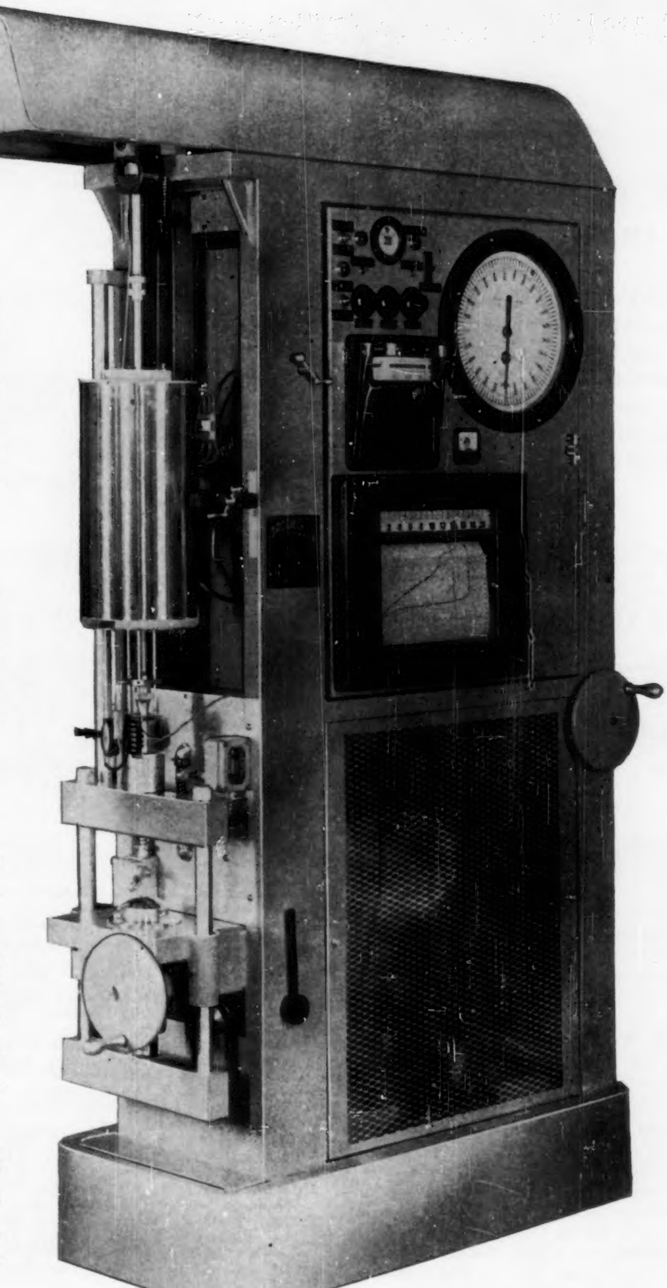
William Arthur Kennedy, supervisor of products, The Grinnell Co., Inc., Providence, R. I.; residence, 31 Forest St., Providence (April 9, 1957, in his 74th year). A member of the Society, and of Committee A-7 on Malleable-Iron Castings since 1941, Mr. Kennedy was serving as Chairman of this main group and its advisory committee at the time of his death. He had headed Committee A-7 for the past eleven years, and had made valued contributions to the committee's activities, specific accomplishments including development and revision of Specifications A 47 for Malleable Iron Castings and A 220 for Pearlitic Malleable Iron Castings, also sponsorship of Specification A 338 for Malleable Iron Flanges, Pipe Fittings and Valve Parts for Railroad, Marine, and Other Heavy Duty Service. He had served too on Committees A-3 on Cast Iron, B-8 on Electrodeposited Metallic Coatings, and E-1 on Methods of Testing, Subcommittee 6 on Indentation Hardness. As a member of the Advisory Committee on Corrosion he arranged for longtime exposure testing of standard malleable, pearlitic malleable, and nodular iron castings, also of steel parts; also aided in the financial program for the corrosion test work. Mr. Kennedy will be greatly missed by those who had worked closely with him, especially the members of Committee A-7. A graduate of Brown University (member of Sigma Xi and Tau Beta Phi), he had been with The Grinnell Co. (formerly General Fire Extinguishers Co.) since 1910. Other organizational affiliations included The American Society of Mechanical Engineers (Gold Star member), Providence Engineering Society (past-president and secretary), Malleable Founders Society (McCrea Award for outstanding service to the malleable casting industry; chairman MFS Technical Council for ten years).

Floyd B. Olcott, member of firm, Shirley, Olcott and Nichols, Washington, D. C. (1956). A member since 1934, Mr. Olcott had served for many years on Committees A-1 on Steel, A-2 on Wrought Iron, A-5 on Corrosion of Iron and Steel, A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, and B-2 on Non-Ferrous Metals and Alloys.

L. W. Walter, consultant on concrete, Jersey City, N. J. (5 Boyd Ave.); in his earlier years, inspecting engineer, Erie Railroad Co. Affiliated with ASTM since 1903, Mr. Walter had been very active for many years in Committees C-1 on Cement, and C-9 on Concrete and Concrete Aggregates; and in recognition of valued contri-

(*Continued on page 58*)

Model "EE" Testing Machine for Creep Rupture and Hot Tensile Testing. Capacities 12,000# as a Creep Tester and 20,000# as a Hot Tensile Tester.



This model features the new fully enclosed cabinet housing all weights, elevator and lever arm. Equipped with automatic cutoff device to shut off power to furnace timer, recorders, controllers and auxiliary apparatus in the event of specimen failure.

Automatic electronic controller working in conjunction with motorized power ram allows specimen to elongate five inches without shock, bending, torsional or cyclic effects and without varying load or axiality.

The Model E-E is equipped with a new type of hydraulic load measuring device that is different from anything ever offered in a testing machine. It consists of a fully isolated shock proof captive circuit having no packing glands, pumps or other troublesome weakness.

It can be supplied as shown with channel recorder, which will print, permanent record of load applied, creep or elongation and one or more temperature records.

ARCWELD MFG. CO.
GROVE CITY, PENNA.

FOR FURTHER INFORMATION CIRCLE 528 ON READER SERVICE CARD PAGE 81

Deaths

(*Continued from page 56*)

butions had been elected to honorary membership in these groups. He served as secretary of Committee C-1 from 1936 to 1942. He also had served on Committee D-8 on Bituminous Waterproofing and Roofing Materials, and ASA Sectional Committee on Specifications and Methods of Test for Hydraulic Cements.

L. E. Welch, metallurgist, McConway and Torley Corp., Pittsburgh, Pa. (January 23, 1957). Member since 1942.

Harold R. Youngkrantz, chief engineer, Apex Smelting Co., Cleveland, Ohio (March 27, 1957). Representative of company membership since 1948, serving on Committees B-2 on Non-Ferrous Metals and Alloys, B-3 on Corrosion of Non-Ferrous Metals and Alloys, B-6 on Die-Cast Metals and Alloys, B-7 on Light Metals and Alloys, and E-2 on Emission Spectroscopy.

NEW MEMBERS.......

The following 90 members were elected from March 21 to April 15, 1957 making the total membership 8844... Welcome to ASTM

Notes—Names are arranged alphabetically—company members first then individuals—Your ASTM Year Book shows the areas covered by the respective Districts

CHICAGO DISTRICT (5)

Mast Development Co., Inc., Dale J. Milnes, manager, Ozone Equipment Div., 2212 E. 12th St., Davenport, Iowa.

Bloomington, Village of, Frank V. Laska, village engineer, 10200 Penn Ave., S., Bloomington 20, Minn.

Carew, William F., chief engineer, Joliet Metallurgical Laboratories, Inc., 31 N. Bluff St., Joliet, Ill. [A]*

Chase, Raymond S., manager, Sales Engineering Dept., Masonite Corp., 111 W. Washington St., Chicago 2, Ill.

Kramer, Robert G., city engineer, City of Waukegan, 106 N. Utica, Waukegan, Ill.

Luther, John P., superintendent, City of Fort Wayne Asphalt Plant and Testing Laboratory, Pape Ave., Fort Wayne, Ind. For mail: 5118 Buell Dr., Fort Wayne 6, Ind.

Mickelson, Grant A., research supervisor, Morton Salt Co., Woodstock, Ill.

Murray, Robert M., partner, James O. Freese and Associates, 25½ N. Water St., Franklin, Ind.

Woodstock, Willard H., chief chemist, Victor Chemical Works, Eleventh and Arnold Sts., Chicago Heights, Ill.

Zartman, John D., director of engineering, Northern Electric Co., 5224 N. Kedzie Ave., Chicago 25, Ill.

CLEVELAND DISTRICT (4)

Everstine, Ralph L., chemist, Eaton Manufacturing Co., Stamping Div., 17877 St. Clair Ave., Cleveland 10, Ohio.

Knapp, Earl O., manager of lab., Hinde & Dauch Paper Co., Sandusky, Ohio.

Miller Furniture Co., Herman, James C. Witty, director, Technical Center, Zeeland, Mich.

WaiMet Alloys Co., Roger F. Waindle, president, 1999 Guoin St., Detroit 7, Mich.

Gumbert, C. W., administrative engineer, Aeroquip Corp., 300 S. East Ave., Jackson, Mich. For mail: 2854 Wolcott Rd., Rt. 4, Jackson, Mich.

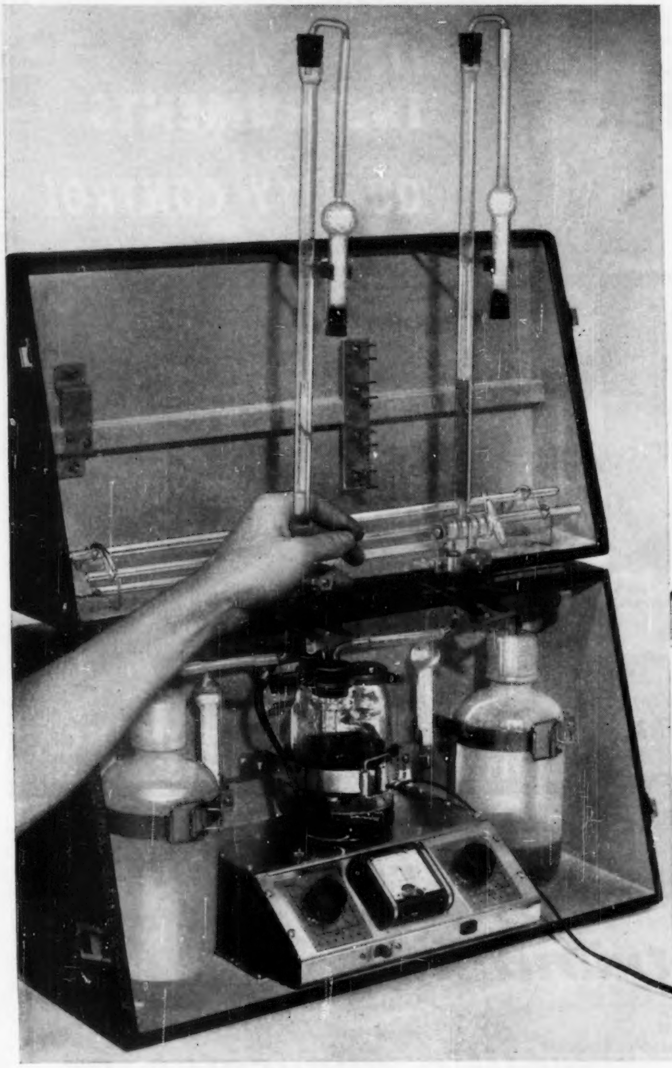
Johnson, Harold B., Jr., estimating engineer, Surface Combustion Corp., 2375 Dorr St., Toledo, Ohio. For mail: 2907½ Robinwood Ave., Toledo 10, Ohio. [A]

Lewis, Bernard J., director, Dept. of Chemistry and Metallurgy, X-Ray Inc., 13931 Oakland Ave., Highland Park 3, Mich.

Nelson, Ronald S., package testing engineer, The Dow Chemical Co., Packaging Dept., Midland, Mich.

* [A] denotes Associate member.

(*Continued on page 62*)



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FOR FURTHER INFORMATION CIRCLE 531 ON READER SERVICE CARD PAGE 81

Deaths

(*Continued from page 56*)

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WaiMet Alloys Co., Roger F. Waindle, president, 1999 Guoin St., Detroit 7, Mich.

Gumbert, C. W., administrative engineer, Aeroquip Corp., 300 S. East Ave., Jackson, Mich. For mail: 2854 Wolcott Rd., Rt. 4, Jackson, Mich.

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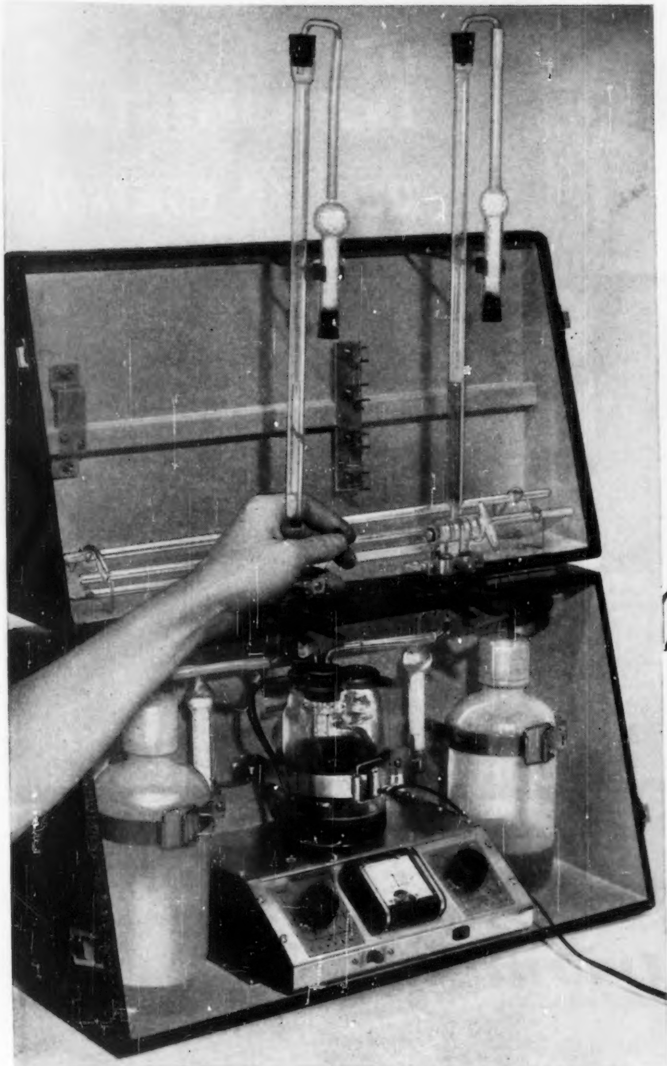
(*Continued on page 62*)



New Members

(*Continued from page 58*)

NEW ENGLAND DISTRICT (13)

Exeter Manufacturing Co., John A. Henry, assistant technical director, Exeter, N. H.

Cerow, J. A., vice-president, in charge of engineering, The Chapman Valve Manufacturing Co., 203 Hampshire St., Indian Orchard, Mass.

Giuliani, Henry G., operating director, engineering, Gabriel Electronics Div. of the Gabriel Co., 135 Crescent Rd., Needham Heights 94, Mass.

Lewis, Ray M., technician, Polymers Inc., Middlebury, Vt.

Mabb, William S., acting chief engineer, The Chapman Valve Manufacturing Co., 203 Hampshire St., Indian Orchard, Mass.

Wentworth Inst., 550 Huntington Ave., Boston 15, Mass.

NEW YORK DISTRICT (1)

New York Wool Trade Assn., Jack H. Willis, director, 16th Fl., 67 Wall St., New York 5, N. Y.

Dixon, W. A., manager, sales service, American Mineral Spirits Co., Mountain Ave., Murray Hill, N. J.

Frick, Ralph, chemist, Secon Lab., Secon Metals Corp., 7 Intervale St., White Plains, N. Y.

Grinthal, Robert D., project leader, American Electro Metals Div. of Firth Sterling Inc., 320 Yonkers Ave., Yonkers, N. Y.

Kenney, E. F., chief chemist, U. S. Customs Laboratory, 201 Varick St., New York 14, N. Y.

Lipkind, Henry, director of product development, Building Product Div., L. Sonneborn Sons, Inc., Hancox Ave., Belleville 9, N. J.

Rudo, Stephen I., director of research and development, Werner Textile Consultants, 1889 Palmer Ave., Larchmont, N. Y.

Singleton, Jerry, executive secretary, The Magnesium Assn., 122 E. 42nd St., New York 17, N. Y.

NORTHERN CALIFORNIA DISTRICT (8)

Thomas, Curtis R., electrical engineer, General Electric Co., 5441 E. 14th St., Oakland 1, Calif.

OHIO VALLEY DISTRICT (15)

Ohio, State of, Division of Lands and Soil, John W. Ferguson, chief, 553 E. Broad, Columbus 15, Ohio.

PHILADELPHIA DISTRICT (2)

Langston, Samuel M., Co., H. W. Moser, chief engineer, 1930 S. 6th St., Camden 4, N. J.

Tele-Dynamics, Inc., M. J. Mozenter, material quality manager, 32nd and Walnut Sts., Philadelphia 4, Pa. [S]**

Ibsen, William, plastics laboratory, Ciba Co., Inc., Kimberton, Pa. [A]

McAdams, Daniel H., engineer, Department of Engineer of Buildings, Bell Telephone Co., Rm. 406, Widener Bldg., 1329 Chestnut St., Philadelphia 7, Pa.

Myers, H. C., Jr., engineer of tests, Midvale-Heppenstall Co., Nicetown, Philadelphia 40, Pa.

Schmid, Werner E., assistant professor, Department of Civil Engineering, Princeton University, Engineering Bldg., Princeton, N. J.

PITTSBURGH DISTRICT (3)

Cline, C. William, head, nondestructive testing section, Physical Metallurgy Div., Alcoa Research Laboratories, New Kensington, Pa.

Grater, Charles W., service metallurgist, United States Steel Corp., 525 William Penn Pl., Pittsburgh 30, Pa. For mail: 1021 Grandview Ave., Pittsburgh 37, Pa.

Kinney, S. P., president, S. P. Kinney Engineers, Inc., 201 Second Ave., Carnegie, Pa.

Kubli, Fred, Jr., metallurgist, McConway & Torley Corp., 109 48th St., Pittsburgh 1, Pa.

** [S] denotes Sustaining member.

(*Continued on page 64*)

New Members

(*Continued from page 62*)

ST. LOUIS DISTRICT (9)

Emerson Electric Manufacturing Co., The, Carlo Sonnino, research physicist, 8100 Florissant Ave., St. Louis 21, Mo.
Hughes, Howard J., chemist, The Eagle-Picher Co., Box 290, Joplin, Mo.
Middleton, W. B., chemical engineer, Lehigh Portland Cement Co., Iola, Kans.
Wisegarver, Gerald, steam service supervisor, Westinghouse Electric Corp., 101 W. 11th St., Kansas City 5, Mo.

SOUTHERN CALIFORNIA DISTRICT (7)

Consulting and Testing Laboratories, A. E. Myers, owner-director, 3126 Niles, Bakersfield, Calif.
Shamban and Co., W. S., F. R. Chaffin, vice-president, 11617 W. Jefferson Blvd., Culver City, Calif.
Ashcom, Charles W., senior metallurgical engineer, Kaiser Steel Corp., Box 217, Fontana, Calif.
Aubrey, Richard, metallurgical engineer, Kaiser Steel Corp., Box 217, Fontana, Calif.
McKeown, John M., chief engineer, Associated Piping and Engineering Co., Inc., 1707 W. Compton Blvd., Compton, Calif.
U. S. Department of the Navy, Yards and Docks Supply Office, Commanding Officer, Port Hueneme, Calif.

SOUTHWEST DISTRICT (16)

Gulf Reduction Corp., Thomas E. Winslett, sales manager, Box 611, Houston 1, Tex.
Dillon, C. P., corrosion engineer, Carbide and Carbon Chemicals Co., Box 471 Texas City, Tex.
Seefield, E. Warren, chemist, Esso Research Labs., Esso Standard Oil Co., Box 551, Baton Rouge 1, La.
Whitmire, Clyde P., welding engineer, Hobart Bros., Co., Troy, Ohio. For mail: 1535 S. Yale St., Tulsa 12, Okla.
Winesett, Joseph G., laboratory group leader, Carbide and Carbon Chemicals Co., Texas City, Tex. For mail: 13 Broadmoor Circle, LaMarque, Tex.

WASHINGTON, D. C., DISTRICT (14)

Cranch, R. C., assistant to director of research, Timber Engineering Co., 1319 18th St., N. W., Washington, D. C.
Cullen, William C., technologist, National Bureau of Standards, Washington 25, D. C.
Klaasse, James M., chief engineer, American Instrument Co., Silver Spring, Md.
Morgan, A. Duke, chief research engineer, State Highway and Public Works Commission, Raleigh, N. C. For mail: 913 W. Johnson St., Raleigh, N. C.
Roberts, Walter L., laboratory technician, Superior Cable Corp., Hickory, N. C. [A]
Thomason, W. A., Jr., president and treasurer, Thomason Textile Service, Inc., Box 8073, Charlotte 8, N. C.
Walker, Richard S., chief chemist, Virginia Rubber Corp., Subsidiary of H. O. Canfield Co., Box 529, Clifton Forge, Va.

WESTERN NEW YORK-ONTARIO DISTRICT (10)

Baird, R. G., chief engineer, N. Slater Co., Ltd., Box 271, Hamilton, Ont., Canada.
Hart, John J., research director, Dollinger Corp., 11 Centre Pk., Rochester 3, N. Y.

U. S. AND POSSESSIONS

Southern Testing and Inspection Laboratory at Orlando, P. J. Conner, president, 830 Clay St., Winter Park, Fla.
Kindsvater, E. F., president and general manager, Farm Chemical Resources Development Corp., 602 W. Greene St., Carlsbad, N. Mex. For mail: Box 625, Carlsbad, N. Mex.
Mississippi, University of, serials section, Library, University, Miss.
Moffitt, J. Kelly, materials engineer, Colorado Materials Co., Box 183, Colorado Springs, Colo. [A]
Morris, Horton H., research director, Southern Clays, Inc., Gordon, Ga.
Murphy, James F., senior test engineer, development and test lab., ACF Industries, Inc., Nuclear Energy Products Div., 336 Woodward Rd., Albuquerque, N. Mex. For mail: 1204 Arizona, N. E., Albuquerque, N. Mex.
U. S. Department of the Navy, Area Public Works Office, Marianas, Area Public Works Officer, Navy No. 926, c/o FPO, San Francisco, Calif.
U. S. Department of the Navy, Public Works Dept., Naval Air Station, Civil Engineers Branch, Design Div., Cecil Field, Fla.
Wheeler, Charles E., testing and inspection, Arizona Testing Laboratories, 817 W. Madison, Phoenix, Ariz. For mail: 2917 N. Nineteenth Ave., Apt. 4, Phoenix, Ariz.

OTHER THAN U. S. POSSESSIONS

Algoma Steel Corp., Ltd., Walter Kimball, assistant chief metallurgist, Sault Ste. Marie, Ont., Canada.
Ribbon Fabric Co. of Cuba, S.A., Isaac Behar, general manager, Muralla 424, 4° Pisu, Havana, Cuba.
Bushell, Thomas Wyvern, principal surveyor for metals, Lloyd's Register of Shipping, 71 Fenchurch St., London E. C. 3, England.
Dempsey, John G., civil engineer and general manager, Compañia Anonima de Concreto, Bachaquero, Estado Zulia, Venezuela. For mail: CADECO, c/o Shell Oil Co., Bachaquero, Estado Zulia, Venezuela.

(*Continued on page 66*)

New Members

(*Continued from page 64*)

Dorsey, Ernest Hayes, soils engineer, Morrison-Knudsen, Inc., San Francisco, Calif. For mail: Morrison-Knudsen, Ltd., Basra, Ashar Q., Iraq.

Escuela Especial de Ingenieros Industriales, Bilbao, Spain.

Estrada Gomez, Enrique, engineering inspector, Secretaria de Est. de Obras Publicas, Ensanche Radhames, Trujillo City, Dominican Republic. For mail: Calle Duarte 58, Trujillo City, Dominican Republic. [A]

Knuth-Winterfeldt, Eggert, professor of metallurgy, Metallurgical Dept., Danish Technical University, Øster Voldgade 10, Copenhagen, Denmark.

Meister, W. D., chief engineer, Terry Machinery Co., Ltd., 6045 Cote de Liesse Rd., Montreal 9, P. Q., Canada.

Morgan, Merton B., materials engineer, Materials Branch, Department of Public Works, Fredericton, N. B., Canada.

Olesen, W., chief chemist, Roulunds Fabriker, Ltd., Rugardsvej 101, Odense, Denmark.

Pun, Peter Yen-Shou, assistant laboratory engineer, Contractors' Lab., Kai Tak Airport Development, Kowloon, Hong Kong, B. C. C. For mail: 118 Tsat Tse Mui Rd., 1st fl., North Point, Hong Kong, British Colony.

Sewell, L. J., general manager, Swan Portland Cement, Ltd., Portland House, Rivervale, Western Australia.

Worldwide Crystallographic Meeting in Montreal

THE INTERNATIONAL Union of Crystallography will hold its Fourth General Assembly and International Congress in Montreal July 10 to 17, 1957. Special symposia will be held on July 18 and 19. The headquarters and most of the sessions will be at McGill University.

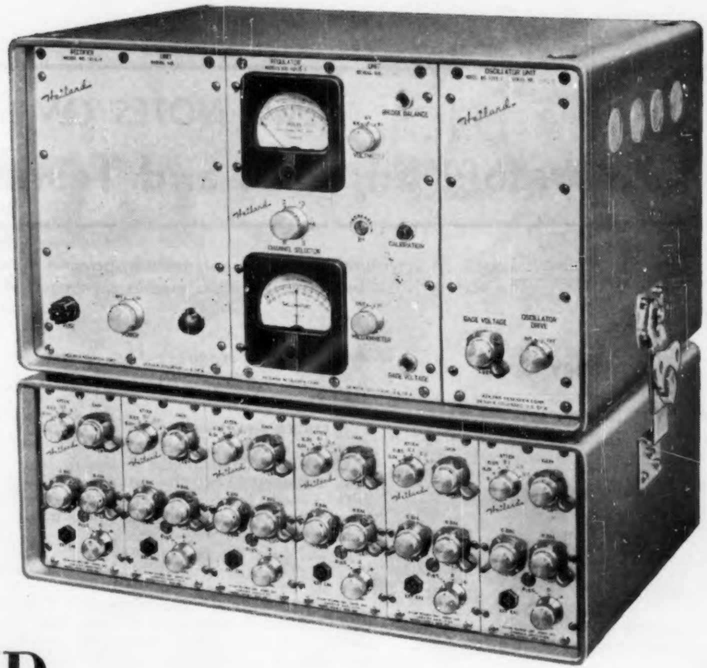
Four general lectures will be given during the Congress as follows:

Proteins by D. Crowfoot Hodgkin
Imperfect Structures by P. B. Hirsch
Crystal Chemistry by G. S. Zhdanov
Clay Minerals by G. W. Brindley

Two symposia will be held on (1) physical techniques of crystallographic interest, other than X-ray, electron or neutron diffraction, with emphasis on paramagnetic and nuclear magnetic resonance, and (2) on electron diffraction studies of solids and gases. Many papers on other subjects of special interest will also be included.

General inquiries about the Montreal meetings should be addressed to the chairman of the Local Committee, W. H. Barnes, Division of Pure Physics, National Research Council, Ottawa 2, Ontario, Canada, in an envelope clearly marked personal.

In conjunction with the assembly, the meeting of the Joint Committee on Chemical Analysis by Powder Diffraction Methods will be held on July 12. The Joint Committee is a cooperative effort of the Crystallographic Assn., ASTM, British Institute of Physics, and the National Association of Corrosion Engineers.



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  50 ma into 20-ohm load
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  less than 2% variation with line voltage fluctuation and wide range of ambient temperatures

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All operating controls are on the front panel; all cabling is on the back panel for handy relay rack or test bench mounting without modification.

The 119 System is flexible to meet present or future needs, since all 6 individual amplifier units within the system are easily removable. You can build your system from the ground up, adding new individual units as your need expands.

In addition, linear-integrate and carrier units are interchangeable within the system case.

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FOR PERFORMANCE AND CONVENIENCE—CHOOSE THE HEILAND 119 AMPLIFIER SYSTEM.

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FOR FURTHER INFORMATION CIRCLE 542 ON READER SERVICE CARD PAGE 81

NEWS NOTES ON

Laboratory Supplies and Testing Equipment

Note—This information is based on literature and statements from apparatus manufacturers and laboratory supply houses. The society is not responsible for statements advanced in this publication.

LABORATORY ITEMS

Pulse Oscillator—Model PG-650, a high-power pulse oscillator with frequency 6-80 megacycles in 5 ranges is now available.
Arenberg Ultrasonic Laboratory, Inc. 1336

Test Dishes—Aluminum test dishes, spun to 1 in. depth are now available for use in test D 988–51 T.
Atmosphere Control Co., Inc. 1337

Micro-Balance—A new portable micro-balance which weighs less than 12 lb is available.
Central Scientific Co. 1338

Torque Tester—The new 311-RT/DY and 321-RT/DY Running Torque Testers supply a need for torque testers where the user does not require a high degree of accuracy.
John Chatillon & Sons 1339

Pressure Calibration Tester—Accurate pressure calibrations not ordinarily possible with oil dead-weight testers or mercury manometers can now be accomplished with a new primary pressure standard. The instrument is known as Type 6-201 Primary Pressure Standard.
Consolidated Electrodynamics Corp. 1340

Portable Mass Spectrometer—Type 21-611 Mass Spectrometer is being introduced for analyzing extremely small amounts of gaseous mixtures or liquids capable of being vaporized.
Consolidated Electrodynamics Corp. 1341

Magnetic Tape Recorder—A new magnetic tape recorder/reproducer system, designed to handle analog, PDM, and FM signals, has been announced.
Consolidated Electrodynamics Corp. 1342

Combustion Tester—This unit is suitable for determination of S. I. temperature of plastics and other solids; and for evaluation and classification of any combustible or noncombustible materials.
Custom Scientific Instruments, Inc. 1343

Stainless Steel Hardening Test—A new low-temperature chilling machine, Model 3SR-120-47 has a 47 cu ft chamber and a net thermal capacity of approximately 6000 Btu per hr at 120 F.
Cincinnati Sub-Zero Products 1344

Contour Projector—A new contour projector, Model 14-6, has been introduced. The projector embodies a micrometer device for horizontal measurements and features ample table travel to simplify staging.
Eastman Kodak Co. 1345

Pocket Microscope—Instrument contains a precision, glass-etched reticle calibrated for measurements up to 1/10 by 0.001 in. divisions. Chrome reflector at base of instrument reflects light on object examined or measured.
Edmund Scientific Co. 1346

Vacuum Gages—Vacuum gages with single-contact relay control for auxiliary circuits are now available for the three general use ranges. Ranges available are 0–100 microns Hg (Model CL-1), 0–1000 microns Hg (Model CV-1), and 0.1–20 mm. Hg (Model CP-1).
Hastings-Raydist 1347

Fatigue Testing Machine—Features the dead-weight static force system. Multi range.
The Ivy Co. 1348

Turbo-Convection Ovens—The turbo-convection features a close heating chamber gradient of ±3 deg F. This low gradient is made possible by a combination of full muffle directed forced convection and recirculation.
L & L Mfg. Co. 1349

Non-Inductive Dummy Load—Available with fixed resistances from 5 to 200 ohms, the Levinthal Model G6A dummy load can be supplied with tapped resistances.
Levinthal Electronic Products, Inc. 1350

Uniformly Labelled D-Mannose—D-Mannose, uniformly labelled, has been added to the list of over 160 radioactive carbon-14 compounds now available.
Nuclear Instrument & Chemical Corp. 1351

Pulse-Height Analyzer—A 100-channel quartz line pulse height analyzer (Brookhaven type) for the rapid accumulation of

(Continued on page 70)

Laboratory Items

(*Continued from page 68*)

data on the amplitude distribution of electrical pulses arriving at random time intervals is available.
Nucleonic Corp. of America 1352

Stress-Rupture and Creep Testing Machine—A new combination stress-rupture and creep testing machine has been developed. The Air-O-Stress-Rupture and Creep Testing Machine is air operated and provides complete versatility for all types of stress-rupture and creep tests.
Tinius Olsen Testing Machine Co. 1353

Pressure Balance—Precision-built pressure balances rated up to 60,000 psi, including measuring cylinder and piston, rotating mechanism, and weight carrying system are available.
Philips Electronics, Inc. 1354

Timer—Timer is intended for use on 115 volt ac and will perform the many timing operations for technical and industrial applications that require accurate repeat timing.
Photo Materials Co. 1355

Dynamic Strain Analyzer—The PA-2A Dynamic Strain Analyzer provides the stable amplification and precise control required for the accurate measurement and oscilloscope display of static and dynamic strain.
Polyphase Instrument Co. 1356

Ultrasonic Degreaser—A compact, small-scaled duplicate of large ultrasonic degreasers has been developed. This bench model can be used in engineering institutions, colleges, and chemical testing laboratories.
Ramco Equipment Corp. 1357

Solvent Extractor—New extractor is useful for laboratory extraction of solid materials.
Roweg Apparatus Co. 1358

Hardness Testers—Two new motorized combination hardness testers have been announced. Available as standard models in both the 8 and 12 in. vertical capacity, reduces operator fatigue by motorization of the major load.
The Torsion Balance Co. 1359

Diodes—A series of silicon diodes capable of operation at 375 C and storage at 400 C which cover the current range from 100 milliamp to 1 amp have been developed.
United States Dynamics Corp. 1360

Multi-Directional Abrasion Tester—A new multi-directional abrasion tester for durability studies of materials whose end-use subjects them to a rubbing and twisting type of wear. The instrument finds utility in testing such materials as floor finishes and coverings, wall paper and wall paper cleaners, etc.
United States Testing Co., Inc. 1361

Testing of Rockets—Model WE-3-125 + 350 for electronic testing and stabilization of metals has a temperature range from −125 F through ambient to +350 F. Pull-down time from ambient to −100 F is approximately 45 min, to −125 F in approximately 1 hr.
Webber Corp. 1362

Roughness Measuring Instrument—A new instrument for the measurement of surface roughness features low cost and simplicity of operation. RoDi, the name of the instrument and standing for Roughness Operated Displacement Integrator, will measure surface asperities in the microinch range.
Williamson Development Co., Inc. 1363

CATALOGS AND LITERATURE

Induction Heating—New, 12-page induction heating "Review" describes laboratory applications of this kind of heating.
Apex Graphic Co. 2227

Industrial Gas Chromatograph—A four-page brochure describing the new Beckman Model 220 Industrial Gas Chromatograph is available.
Beckman Instruments, Inc. 2228

Humidity Chamber—Two page, *Bulletin No. 5670*, illustrates the vapor-temp point programming recording controlling humidity chamber.
Blue M Electric Co. 2229

Strain Gage—A new four-page catalog sheet, detailing strain gage apparatus, Model BL-1516, has been released. The instrument is a unit for measuring both static and dynamic strain.
Brush Electronics Co. 2230

Ultrasonic—*Metals Digest* contains articles on Ultrasonic Cleaning and Negative Development.
Buehler Ltd. 2231

(*Continued on page 74*)


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Greater accuracy and reproducability achieved with new modulated temperature control.

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A constant volume of air at a controlled temperature in the heavily insulated cabinet, maintains uniform predetermined specimen temperatures regardless of variations in room conditions.

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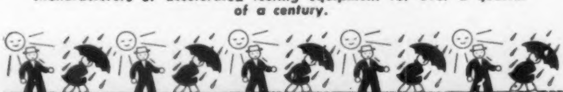

CIRCLE 548 ON READER SERVICE CARD PAGE 81

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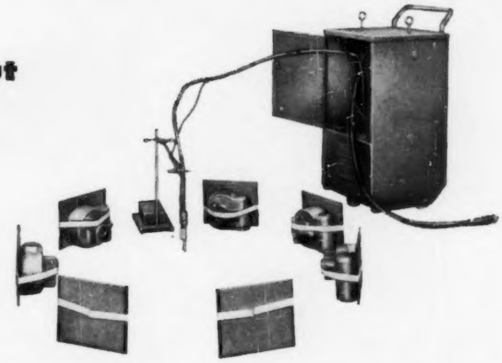
some people have queer notions about

RADIOGRAPHY WITH ISOTOPES



Here's a typical multiple-specimen setup . . . seven castings radiographed simultaneously with a T.O. model 402 panoramic Cobalt 60 unit.

Many a plant, uneasily aware that it is missing the profits of radiographic inspection, still holds back for one mistaken "reason" or another. Here are some we run into . . .

"out of my league" . . . *costs too much*

Not so. An iridium 192 machine costing as little as $1700 may be fully adequate to your needs. *Indeed, average equipment cost is less than $2500.*

needs a *specialist* to run

On the contrary, a practical on-the-job training course in our Cleveland laboratory (free tuition to buyers) equips any intelligent employee with all he has to know.

takes forever to make a radiograph

Not so. You can x-ray 1" steel in 30 seconds, 3" sections in 4 minutes with the Cobalt 60 sources available today.

gamma radiographs are no good

Not so. If you use the right source for the right job you'll have no trouble getting the 2% detail sensitivity required by exacting inspection codes.

it's dangerous; we're afraid of it

No reason to be: Technical Operations modern equipment is safe and simple-to-handle.

not for me; my stuff is different

We don't know what *your* business is . . . but if *whatever* you make (or buy or sell) needs "seeing into" for quality control, radiography (either gamma or x-ray) can profit you as it does others — *your competitors included.*

The compact source capsule easily enters into pipes and hollow vessels to radiograph "inside out."

costs nothing to find out

what radiography can do for you. Simply call in your local Picker representative* or write us outlining your problem (and if possible, sending typical samples). We'll make tests and tell you frankly whether radiography holds any promise for you. Because Picker offers *both* x-ray and isotope equipment, we have no axe to grind for any particular method.

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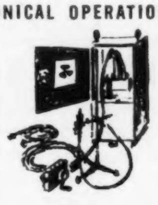
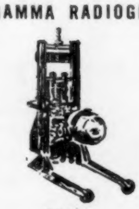
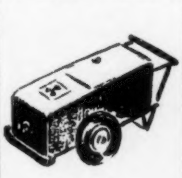


TO402
Cobalt 60 Unit

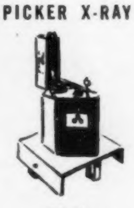


TO404
Cobalt 60 Unit



TO446
Cobalt 60 Unit

TO405
Iridium 192 Unit



TO416
Source Changer

one stop for everything in Picker x-ray **radiography and fluoroscopy**

FOR FURTHER INFORMATION CIRCLE 550 ON READER SERVICE CARD PAGE 81

Catalogs and Literature

(*Continued from page 70*)

Multi-Channel Oscilloscopes—A new 28-page catalog describes a complete line of standard 2- and 4-channel oscilloscopes, strainalyzers, and related d-c amplifiers.
Electronic Tube Corp. 2232

Brinell Testing—A new bulletin, *Bulletin No. A-15*, covers methods and machines for rapid, standard Brinell hardness tests in routine production.
Gries Industries, Inc. 2233

Glassware Catalog—New 234-page Technical Glassware *Catalog No. T6-15* contains current prices on 11,130 items of laboratory and scientific glassware.
Kontes Glass Co. 2234

Flowmeter—A new four-page, *Product Data Sheet 463-170*, describing the Centrimax Flowmeter is available.
Leeds & Northrup Co. 2235

Amplifier—400 and 60-cycle magnetic amplifier data and specifications are provided in a 16-page Product Catalog.
Litton Industries 2236

Nondestructive Testing—A new booklet, *A Manual on Zyglo and Zyglo-Pentrex*, for nondestructive testing is now available.
Magnaflux Corp. 2237

Radioactivity Measuring—A new 64-page two-color catalog has been issued. It illustrates and describes over thirty new radioactivity measuring instruments introduced since the last edition.
Nuclear Instrument & Chemical Corp. 2238

Radiation Monitor—Complete monitoring systems for the detection, recording, and warning of airborne particulate radioactivity are described in new 6-page *Bulletin AM-57*.
Nuclear Measurements Corp. 2239

Radiography—A new 6-page bulletin titled *Radiography in Production Control and Inspection of Subminiature Tubes* describes techniques.
Philips Electronics, Inc. 2240

Chemical Catalog—The 1957 edition of the Reilly Chemical Index has been published. The brochure contains information on eight new compounds and lists all chemicals available from the company.
Reilly Tar and Chemical Corp. 2241

Specific-Gravity Apparatus—Leaflet describes instrument which supports interchangeable hydrometer vessels in accurately vertical position on a swinging arm, thus providing accessible location for hydrometer near a laboratory sink or mounted on a standard laboratory tap.
Royco Instruments 2242

Identicharts—A new, two color, four-page folder illustrates and describes Royson Identicharts that record on strip charts from a remote point the exact time or sequence conditions occur during process control and test work.
Royson Engineering 2243

What's New for the Laboratory—The 28th edition of 16 pages, "What's New for the Laboratory," is available.
Scientific Glass Apparatus Co., Inc. 2244

Catalog—The March, 1957 issue of *Lab-Oratory* features 16 pages of new scientific equipment.
Schaar & Co. 2245

Soil Testing Manual—The unconfined compression test for cohesive soils is described in detail in a new testing manual. Standard engineering test procedures using laboratory equipment especially designed for performing the soil compression tests are outlined in the 56-page manual.
Soiltest, Inc. 2246

Instrument Details—*Instrument Notes No. 31*, describes the characteristics of flat annular diaphragms.
Statham Laboratories, Inc. 2247

Low Temperature—A new 4-page folder, *Bulletin No. 2-27*, illustrates six different models of standard subzero industrial freezers. Units are available, mechanically operated, from −225 to 350 F.
Webber Corp. 2248

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MPS
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UNITRON METALLURGICAL — Models MMU, MMA

MMU: for metals and opaque specimens and also transparent specimens under both ordinary and polarized light. Vertical, oblique and transmitted illumination. Transformer housed in microscope base. Focusable stage, polarizing apparatus and filters. Objectives: 5X, 10X, 40X, 100X. Eyepieces: P5X, P10X, K15X.

MMA: a simplified version of MMU, 25 – 600X.

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MMA
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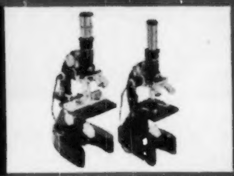

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MPEA
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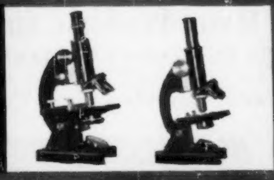

UNITRON PHOTOMICROGRAPHY SET — Model ACA

Duplicates the performance of costly apparatus. Mounting brackets adjust to accommodate your present camera (35 mm., No. 120, No. 127, etc.). Viewing telescope permits all adjustments to be made while camera is in place and allows continuous observation of the specimen, even during time exposures.

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UNITRON STEREOSCOPIC — Models MSH, MSL

MSH: for inspection, dissecting and other applications requiring a wide-field, 3-D view with great depth of focus. Inclined binocular head with distance and diopter adjustments. Revolving nosepiece. Choice of 3 objectives among 1X, 2X, 3X, 6X. Eyepieces: 8X, 12X, 15X. Models with both high and low stands.

MSL: single-magnification stereo with vertical binoculars.

MSH
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MSL
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FOR FURTHER INFORMATION CIRCLE 553 ON READER SERVICE CARD PAGE 81

INSTRUMENT COMPANY NEWS

The Budd Co., Philadelphia, Pa.—Bruce L. Sutton has been named sales manager, of the Tatnall Measuring Systems Co.

Consolidated Electrodynamics Corp., Pasadena, Calif.—Directors have approved purchase of the major assets of William Miller Instruments, Inc., of Pasadena, pioneer custom manufacturer of dynamic recording and data-processing equipment.

Consolidated Electrodynamics Corp., Pasadena, Calif.—Consolidated Electrodynamics Corp. is building in Monrovia, Calif., two 57,500 sq ft office, laboratory, and plant buildings to house its transducer and systems divisions.

Electrical Testing Labs., Inc., New York, N. Y.—Gordon Thompson, chief engineer, has been elected vice-president and Robert N. Lankering has been appointed staff assistant to president Hoffman S. Beagle.

Fairchild Camera and Instrument Corp., Syosset, L. I., N. Y.—Sherman M. Fairchild, founder and board chairman, has been elected president of Fairchild Camera and Instrument Corp., succeeding John H. Clough. Three new members also were elected to the Board.

Fisher Scientific Co., Pittsburgh, Pa.—Fisher Scientific, manufacturer and distributor of laboratory instruments, apparatus, and reagent chemicals, has purchased the laboratory apparatus and supply business of E. Machlett & Son.

Philips Electronics, Inc., Mount Vernon, N. Y.—A new Norelco office has been opened in Philadelphia by the Instruments Division, according to an announcement by C. H. Woods, national sales manager. Frank Cavanagh is sales engineer in charge of the Philadelphia office.

Robertshaw-Fulton Controls Co., Anaheim, Calif.—Robertshaw-Fulton Controls Co. will begin construction of a $250,000 Western Research Center shortly.

Will Corp., Rochester, N. Y.—Newest Will laboratory supply and service center is Will Corp. of W. Va., South Charleston 3, W. Va. A modern plant houses large stocks of the equipment, instruments, supplies, and reagent chemicals of over 900 leading manufacturers in the field.

LABORATORY NEWS

Bjorksten Research Labs., Madison, Wis.—James E. Henning has been appointed vice-president of Bjorksten Research Labs. for industry, and Irvin Leichtle has been named administrative assistant.

Evans Research & Development Corp., New York, N. Y.—Continuing expansion of activities at Evans Research and Development Corp. has required the addition of four more chemists to the technical staff, according to an announcement by Eric J. Hewitt, vice-president of the independent chemical consulting laboratory.

General Electric Co., Waterford, N. Y.—Construction of a new product and process development laboratory and further expansion of other facilities of the Silicone Products Dept. of the General Electric Co., has been announced by Charles E. Reed, general manager, and 1956 ASTM Marburg lecturer.

OTHER SOCIETIES' EVENTS

June 2–5—**American Leather Chemists Assn.**, Annual Meeting, Lake Placid, N. Y.

June 2–7—**Society of Automotive Engineers**, Summer Meeting, Chalfonte-Haddon Hall Atlantic City, N. J.

June 3–5—**Chemical Institute of Canada**, Annual Conference, Hotel Vancouver, Vancouver, B. C.

June 3–5—**American Society of Refrigerating Engineers**, 53rd Annual Meeting, Hotel Fontainebleau, Miami Beach, Fla.

June 3–5—**Edison Electric Institute**, Annual Convention, Palmer House, Chicago, Ill.

June 3–7—**American Society of Civil Engineers**, Annual Spring Convention, Hotel Statler, Buffalo, N. Y.

June 3–7—**National Bureau of Standards, 42nd National Conference on Weights and Measures**, Sheraton-Park Hotel, Washington, D. C.

June 6–8—**National Society of Professional Engineers**, Annual Meeting, Statler-Hilton Hotel, Dallas, Tex.

June 6–8—**Manufacturing Chemist's Assn.**, 85th Annual Meeting, The Greenbrier, White Sulphur Springs, W. Va.

June 9–13—**American Rocket Society**, Semi-Annual Meeting, Hotel St. Francis, San Francisco, Calif.

June 9–14—**The American Society of Mechanical Engineers**, Semi-Annual Meeting, Sheraton-Palace, San Francisco, Calif.

June 10–12—**American Nuclear Society**, 3rd Annual Meeting, Penn Sheraton Hotel, Pittsburgh, Pa.

June 13–14—**Malleable Founders' Society**, Annual Meeting, The Broadmoor, Colorado Springs, Colo.

June 14—**Society of Plastics Engineers, Inc.**, Regional Technical Conference, "Plastics for Electronics," Lowell Institute of Technology, Lowell, Mass.

June 16–20—**American Electroplaters' Society**, 44th Annual Convention, Mount Royal Hotel, Montreal, Canada.

June 17–20—**Institute of Aeronautical Sciences**, Annual Summer Meeting, Biltmore Hotel, Los Angeles, Calif.

June 17–21—**American Society for Engineering Education**, Annual Meeting, Cornell University, Ithaca, N. Y.

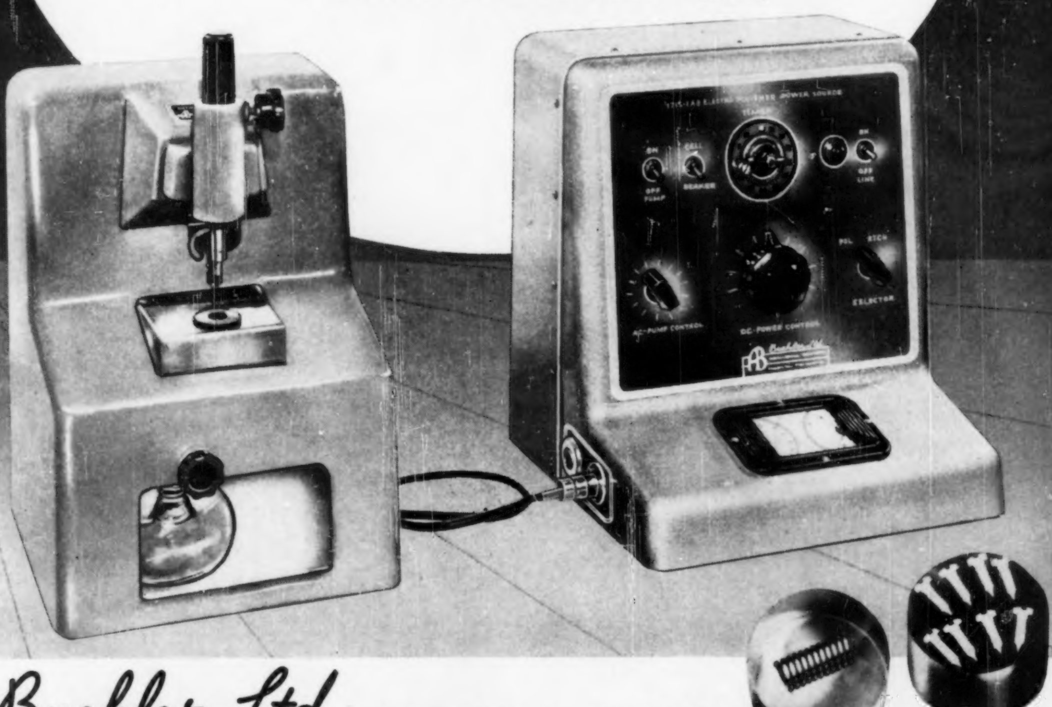
June 18–20—**American Society of Heating and Air Conditioning Engineers**, Semi-Annual Meeting, Manoir Richelieu, Murray Bay, Canada.

June 23–26—**American Society of Agricultural Engineers**, Golden Anniv. Meeting, Michigan State Univ., East Lansing, Mich.

June 23–28—**Forest Products Research Society**, 11th Annual Meeting, Hotel Statler, Buffalo, N. Y.

June 23–28—**National Association of Power Engineers**, National Convention, Pantlind Hotel, Grand Rapids, Mich.

June 24–28—**American Institute of Electrical Engineers**, Summer General Meeting, Sheraton-Mt. Royal Hotel, Montreal, Canada.



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Laboratory Items page 68

One sentence descriptions of new testing machines, laboratory or control apparatus, and related equipment.

Catalogs and Literature Section page 70

Charts, data sheets, catalogs, and other printed matter applicable to research, testing, or production control of engineering materials.

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